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FISH&WILDLIFE HABITAT RESTORATION IN HAMILTON HARBOUR AND COOTES PARADISE

Concept Summary

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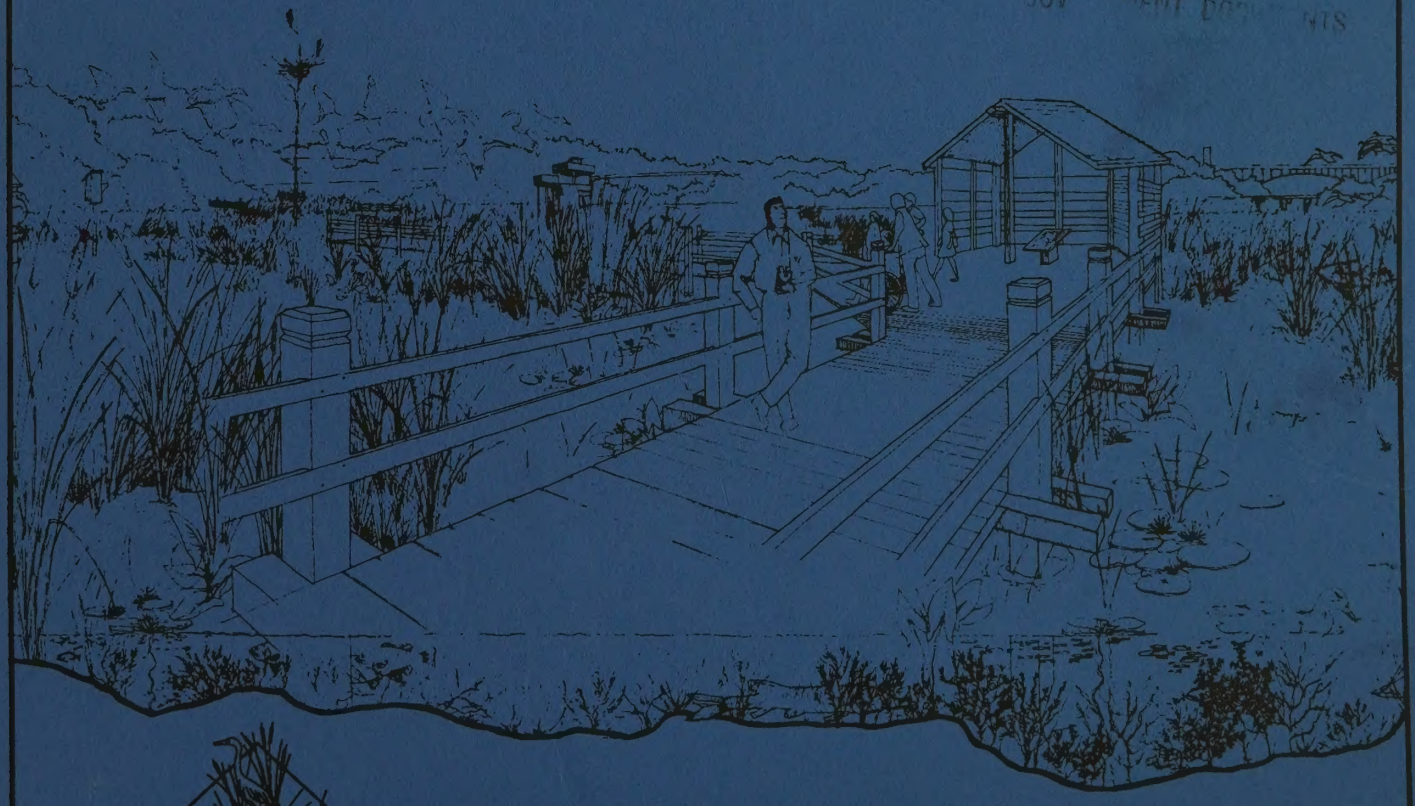

A BETTER PLACE TO LIVE

FISH&WILDLIFE HABITAT RESTORATION IN HAMILTON HARBOUR AND COOTES PARADISE

Concept Summary

DECEMBER 1991

Fish and Wildlife Restoration Committee
for Hamilton Harbour And Cootes Paradise
605 James Street N. (3rd floor) Hamilton, Ontario L8L 1K1

A BETTER PLACE TO LIVE

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PREFACE

The Concept for Fish and Wildlife Habitat Restoration in Hamilton Harbour and Cootes Paradise is a "home grown" initiative that flows from the Hamilton Harbour Remedial Action Plan (RAP). The RAP, which was begun in 1985, was released for review and comment, as a draft, dated December 1991. The initiative to restore fish and wildlife habitat has been evaluated during the course of the RAP's development. It is being initiated at the same time as the RAP is being finalized because it is a RAP component which can be advanced without affecting other components of the RAP.

The Concept has been advanced to the federal Department of the Environment's Great Lakes Cleanup Fund, and has received funding of $4.2 million, contingent upon receiving additional funding from other private and public sector sources.

The contents of this report is a summary, and contains excerpts from the various reports that have been prepared as part of the Hamilton Harbour RAP. In order to appreciate the Concept for Fish and Wildlife Habitat Restoration fully, the reader is encouraged to read the RAP reports and other documents listed in the bibliography.

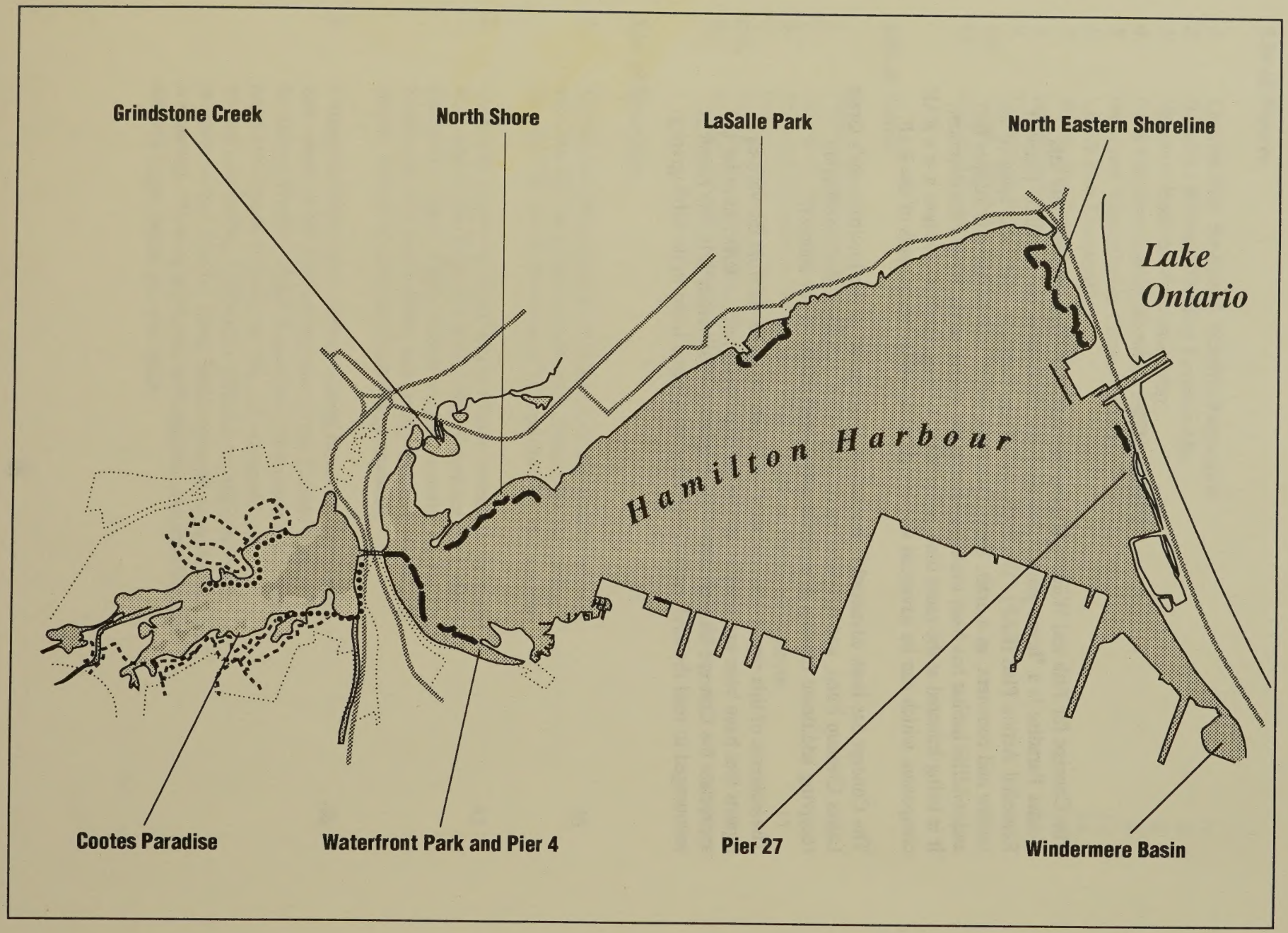


Figure 1. Concept Plan for Fish and Wildlife Restoration

EXECUTIVE SUMMARY

History of Fish and Wildlife in Hamilton Harbour

Hamilton Harbour, a natural bay at the western end of Lake Ontario, consists of a 5 400 ha outer harbour (maximum depth of 22 m) connected to Lake Ontario by the Burlington Ship Canal on the east and to Cootes Paradise, a 400 ha shallow water marsh, on the west. Cootes Paradise discharges into the western end of Hamilton Harbour via a 15 meter wide channel cut through Burlington Heights.

Apart from its obvious historic value as an industrial centre and shipping port, Hamilton Harbour was recognized in the 1800s as a unique fish and wildlife habitat that contributed significantly to commercial and recreational fishing, trapping and hunting. The commercial fishery was dominated by lake trout, whitefish, and herring. Kerr and Kerr, the Fisheries Overseers for Hamilton Harbour from 1860 to 1898, reported extensive feeding migrations into the harbour of lake trout and whitefish in June and July followed by spawning migrations in October and November as millions of herring and whitefish entered the harbour to spawn on the rocky shoals along the north shore.

Almost all of Cootes Paradise and the south and west shores of Hamilton Harbour consisted of shallow water marshes that provided spawning, nursery, and adult habitats for the warmwater fish community. Pike and bass were the dominant recreational and commercial warmwater species. Approximately 12 270 kg of pike were taken by the commercial fishery in 1871 and bass fishing peaked in 1879 with a record catch of 5 400 kg. The diverse warm water fishery included pike, bass, yellow perch, sunfish, muskellunge, walleye, drum, burbot, channel catfish, brown bullhead, and white sucker.

There is little quantitative information on the numbers of wildlife species inhabiting the marshes of Cootes Paradise and Hamilton Harbour. Wragg, in 1949 described the marsh circa 1920, "Judging from reports of its condition, 30 years ago it must have been a remarkable place. In addition to the abundant growth of aquatic plants found there today, wild celery was common and wild rice so abundant that rowing through the marsh, one's boat would be covered with rice. Water was so clean and food so plentiful that ducks remained in thousands until ice formed." Charles Durand wrote that in 1818-19, Cootes Paradise "was a paradise for game of all kinds. Immense flocks of ducks and wildfowl and wild animals innumerable in old times were seen there. It was also the resort of wild fur animals, such as otter, perhaps beaver, fisher, minks, and especially muskrats; snakes were abundant there of all kinds". In 1861, McIllwraith described flocks of waterfowl in Hamilton Harbour "so great as frequently to darken the light of sun by day and make the night hideous with their discordant cries".

Decline of fish and wildlife communities

By 1900, the cold water fishery was responding to deteriorating water quality, competition from exotic species, exploitation, and habitat loss associated with urban and industrial development. The first collecting sewer for the city of Hamilton was completed in 1854. Prior to this, sewage disposal from 'water closets' emptied directly into Cootes Paradise and Hamilton Harbour and the combined effects of low dissolved oxygen, increased ammonia, acute toxicity of bottom sediments to important benthic species, spills of toxic substances in the littoral zone, exploitation and finally competition with invading species were sufficient to drive the cold water fishery to extinction. Commercial catches of lake trout,

whitefish, and herring which peaked at 4 500, 13 600 and an impressive 114 000 kg per year respectively in the late 1800s dwindled to 0, 273, and 70 kg, by 1940 and disappeared completely by 1956.

The collapse of the coldwater fishery was quickly followed by a rapid decline in warmwater fish and wildlife populations. Habitat destruction was undoubtedly the most significant factor affecting nearshore fish and wildlife communities that relied on tributary streams and shallow marshes for protection, food and reproduction. Population growth in Hamilton was accompanied by rapid industrial expansion along the south shore of the harbour. By 1912, the harbour was receiving effluents (organics, metals, nutrients, solvents, and dyes) from three municipalities, two of Canada's largest steel producers, and textile, rubber, paint, and solvent manufacturers. As a result, littoral areas bore the full impact of municipal and industrial discharges. There are many references in the Kerr diaries documenting fish and wildlife mortality along the south shore.

By 1926, industrial expansion was spreading rapidly along the south shore from west to east. Vast amounts of shallow productive marsh were filled to accommodate roads, piers, railways, and factories. This trend continued in the post war years and by 1959, approximately 22 percent of the open water area in the harbour had been lost to landfilling. Although development along the south shore significantly reduced the open water area (and the retention time of the bay); the most significant impact was the loss of the shallow water marsh habitats that supported extensive fish and wildlife communities along the south shore. Prior to industrial development, the 49 km south shore was a complex marsh ecosystem colonized by emergent and submerged vegetation. The irregular shoreline was inundated with inlets that in many cases extended more than 1 km inland.

There is no gently sloping littoral zone (less than 2.5 meters deep) remaining along the south shore east of the Lax property. The shoreline consists of sheet steel pilings and concrete breakwaters. Most is dredged to 8 m deep for shipping. Sediments along the industrial section are heavily contaminated in several locations with metals and organics and are acutely toxic to sensitive benthic organisms. The entire south and east shores of Hamilton Harbour have been filled, dredged, or reinforced with concrete and steel to combat erosion. Historically important fish and wildlife habitat cannot be reclaimed at these sites. Efforts to develop marsh and littoral habitats must concentrate on the less degraded sites in Cootes Paradise, Grindstone Creek, and along the north and east shores. Some opportunities for habitat creation also exist in the south west end of the harbour.

The north shore looks very much as it did historically, with the exception of the armoured shoreline which property owners have constructed to prevent erosion from wave action. Unlike the wide band of littoral habitat that characterized the original south shore, the north shore slopes steeply, and has only a narrow ribbon of littoral habitat available for restoration. Because much of the shoreline is reinforced with breakwalls, it offers no energy dampening effects to wind driven waves, and is characteristic of a high wave energy zone. As a result, light penetration in the littoral zone is impaired by high concentrations of resuspended bottom sediments, and there is insufficient light to support macrophyte growth. Aquatic vegetation is sparse (less than 3 plants/m^2) in fifty-five percent of the littoral zone along the north shore.

The Cootes Paradise marsh has also responded to urban development. Emergent vegetation, once abundant throughout the marsh, declined by 85 percent between 1934 and 1985. Similarly, the distribution, species composition,and abundance of submerged vegetation declined between 1940 to 1970; of the 24 species of submerged and floating macrophytes reported in 1949, only 10 were present in the marsh in 1970. The loss of the extensive marsh in Cootes Paradise is due to the combined effects of high

water levels, increased sedimentation, nutrient enrichment and increased levels of suspended solids resulting from resuspension of bottom sediments from wind and from the foraging activities of carp.

Developing a Habitat Plan

Remedial actions have significantly (>90%) reduced phosphorus, ammonia, organic and metal loadings to the harbour and additional measures are proposed that will restore water quality to support healthy fish and wildlife populations. Unfortunately, much of the habitat damage is irreversible. Experience from other degraded ecosystems that have undergone water quality improvements, suggests that the desired response of fish and wildlife populations to remedial actions will not occur by themselves. These degraded ecosystems are very stable and have internal mechanisms for maintaining their existence. Direct intervention is necessary, hence the philosophy of bottom-up and top-down management of ecosystems.

The concept for fish and wildlife restoration is a component of the Remedial Action Plan for Hamilton Harbour. During the development of the Stage II Remedial Options Report for Hamilton Harbour, many discussions have focused on this very issue. Experts now agree that despite remedial measures targeted at point and non-point pollution, habitat restoration will not occur naturally. Direct intervention will be necessary. Two technical workshops were convened in 1990 to determine a course of action. A consensus was achieved from all parties and it is strongly felt that the restored habitats will not only benefit fish and wildlife populations but will also aid in the improvement of water quality in Hamilton Harbour. Restoration of wetland communities in Hamilton Harbour and Cootes Paradise will greatly assist in the "CLEAN-UP" of this RAP site. To date approximately $600,000,000.00 have been spent by the public and private sectors to improve water quality. The habitat proposals in this report combined with other remedial options to reduce nutrient and contaminant inputs will restore self-sustaining fish and wildlife populations in Hamilton Harbour.

Project Management

The Fish and Wildlife Habitat Restoration Project is managed by the Fish and Wildlife Restoration Committee for Hamilton Harbour and Cootes Paradise. The Steering Committee reports to the Bay Area Restoration Council, which is responsible for monitoring all the remedial actions under the Hamilton Harbour Remedial Action Plan. The Bay Area Restoration Council has been drawn from the Stakeholders Committee, a group of approximately 48 members representing government, industry, and private citizens. The Stakeholder Committee oversees the development of the Hamilton Harbour Remedial Action Plan. The principle landowners include the Royal Botanical Gardens, the Hamilton Harbour Commissioners and the Federal Department of the Environment (Canada Centre for Inland Waters).

Project Goals

In December 1991, the Technical writing Team and Stakeholders released for public review a draft copy of the Stage II Report which outlines in detail the proposed Remedial Action Plan, This draft report identifies the Concept Plan for Fish and Wildlife Restoration for Hamilton Harbour and Cootes Paradise and identifies the specific components of the plan as recommended actions.(potential actions 10 through 14 inclusive, section IV.10.7, Evaluation of potential remedial measures to restore fish and wildlife populations.) and (recommendations 9 through 15 inclusive)

The draft Remedial Action Plan contains a series of goals several of which are directly related to fish and wildlife as follows:

" THAT water quality and fish habitat should be improved to permit an edible, naturally reproducing fishery for warm water species. Water and habitat conditions in Hamilton Harbour should not limit natural reproduction and the edibility of cold eater species."

"THAT healthy and self-sustaining resident and non-resident wildlife populations should be enhanced on a Harbour-wide basis through water quality improvements, habitat rehabilitation and protection".

The goals of the project are to improve water quality in Cootes Paradise and Hamilton Harbour; to alter the fish community from one dominated by pollution tolerant species such as carp and alewife to a community controlled by top predators; to provide spawning, nursery and adult habitats for fish; to recover lost wetlands and create habitats for shorebirds, waterfowl, reptiles and mammals; to create nesting and loafing habitats for colonial nesting birds (such as cormorants, black-crowned night herons, common terns) and feeding habitat for waterfowl, and finally, to provide much needed access to the waterfront and the restored wetland, to improve aesthetics, and to provide educational and recreational opportunities.

Throughout the development of the Preferred Options Report for Hamilton Harbour (preliminary to the Stage 2 RAP), the stakeholders affirmed their goals for increased vegetation in Cootes Paradise and Grindstone Creek and in the littoral zones of Hamilton Harbour. They supported the concept of reefs, islands and other devices to shelter the littoral zone and provide habitat for fish and wildlife. The stakeholders strongly advocate diversity of uses, improved aesthetics, access, and education.

Project Overview

The plan focuses on constructing marsh and littoral habitats to restore fish and wildlife populations. Rehabilitation of the marshes are proposed for Cootes Paradise and Grindstone Creek. At several locations within the Harbour narrow islands are proposed to be constructed to mitigate the effects of erosion and wave action. The sheltered lagoons inside these islands will encourage the growth of submerged aquatic plants, and provide habitat for fish and waterfowl. Some islands will be designated as wildlife habitats to provide nesting and loafing sites for terns cormorants and other colonial birds.

The diverse needs of an urban setting have been considered; the proposal contains options for fishing piers, canoe launch areas, access, interpretive centres, as well as education and wildlife viewing platforms. The concept has eight components or initiatives. These are located in different geographical areas and include:

a) Cootes Paradise (marsh restoration and public access)
b) Grindstone Creek (marsh restoration and public access)
c) Waterfront Park and Pier 4 (fish and wildlife habitat and public access)
d) North Shore (fish and wildlife habitat)
e) LaSalle Park (fish and wildlife habitat and public access)
f) Northeastern Shoreline (fish and wildlife habitat and public access)
g) Pier 27 (fish and colonial bird habitat)
h) Windermere Basin (colonial bird nesting habitat)

1. The project will create 200 hectares of emergent and submerged vegetation in Cootes Paradise. Marsh boardwalks will link existing parks and trails and improve waterfront access and public education. Observation towers will be constructed for wildlife viewing. The restored marsh will trap sediments, nutrients, and contaminants and result in improved water quality in Cootes and the harbour. In addition, restored marsh vegetation will provide important nursery and adult habitats for wildlife and fisheries. A temporary carp barrier and fishway will be installed between Hamilton Harbour and Cootes Paradise to protect the developing marsh from the adverse effects of carp and still permit movement of other fish species between the marsh and the harbour.

2. The only pike spawning marsh in Hamilton Harbour is located in Grindstone Creek. The marsh dewaters early in the season stranding young fish. A new water inlet and low-head dam will be installed to remedy this problem. Aquatic vegetation in the lower Grindstone Creek and Sunfish Pond will be restored to provide important nursery habitat for fish. Exposed mudflats will be retained to encourage shorebirds. A carp barrier and fishway will be installed in the mouth of Grindstone Creek.

3. Narrow islands will be constructed at strategic locations in the harbour to mitigate the adverse effects of erosion and wave action. These are causing water turbidity and limiting submerged aquatic plants in the littoral zone. The islands will create sheltered lagoons which will encourage submerged aquatic plants and provide essential habitat for warmwater fish and feeding habitats for waterfowl. Some islands will be designated as wildlife habitats to provide nesting and loafing sites for colonial nesting birds. Wildlife islands will contain appropriate nesting boxes to encourage desirable species. Measures will be employed to discourage unwanted species such as ring-billed gulls. Other islands will be linked by bridges and boardwalks to encourage pedestrian access to the waterfront and provide opportunities for fishing, walking, and wildlife appreciation. Island creation is proposed for the shallow waters off the former Lax property, between Carrolls' Point and Willow Point, off LaSalle Park, in the north east corner of the harbour near CCIW, and on the east shore south of the canal near Pier 27. Final site selection will depend upon partner support and concerns raised during the Environmental Assessment and Review Process.

Summary of Benefits

1. Improved water quality in Cootes Paradise and Hamilton Harbour by trapping nutrients, sediments, and contaminants in the created marshes and reducing erosion and sediment resuspension behind the islands.

2. Improved fish community (less carp, alewife, white perch and gizzard shad; more pike, bass and perch).

3. Improved plant diversity (increased plant diversity from 4 species to approximately 25).

4. Increased nesting and loafing habitats for colonial birds, and control of ring-billed gulls and Canada geese.

5. Increased abundance and diversity of waterfowl, amphibians, mammals, and birds in the restored Cootes marsh.

6. Maximum diversity of beneficial uses to resource users such as: improved waterfront access, education, fishing, wildlife appreciation, improved aesthetics and enhanced use of the harbour for small boats.

7. Linkages with ongoing pollution control and waterfront development projects to enhance beneficial uses in Hamilton Harbour.

Total new habitat

1. Create 344 hectares of new fish and waterfowl habitat.
2. Create 271 hectares of new wildlife habitat.
3. Provide an additional 10 km of littoral edge for fish.
4. Provide an additional 6 km of waterfront access.

Table 1. Habitat creation at each site

Location	Fish Habitat (ha)	Wildlife Habitat (ha)	Littoral Edge (m)	Trails (m)
Cootes Paradise	250.0	250.0	0	2000
Grindstone Creek	20.0	20.0	0	1000
Pier 27	3.8	0.1	500	0
Northeastern Shoreline	18.4	0.3	2,920	500
LaSalle Park	11.9	0.2	2,340	1,170
North Shore	18.0	0.6	2,550	0
Waterfront Park and Pier 4	22.1	0.4	2,600	1,300
Total	**344.20**	**271.60**	**10,910.00**	**5,970.00**

Funding

Habitat restoration and creation will cost approximately 12.6 million dollars. The concept for fish and wildlife restoration was presented to the Department of Environment's Great Lakes Cleanup Fund. The proposal was accepted and funding for 4.2 million dollars over three years was approved conditional on partner contributions for the remaining 8.4 million dollars needed to complete the project. The Fish and Wildlife Restoration Steering Committee, which represents the Stakeholders, is soliciting support from public and private partners for this important project.

Next Steps in the Process

The concept for Fish and Wildlife Restoration Habitat Restoration in Hamilton Harbour and Cootes Paradise has been defined, and can now proceed through the federal Environmental Assessment and Review Process.

The next stage of this process is the Preliminary Scoping Stage which identifies public issues and concerns, defines valued ecosystem components, secures funding and negotiates with land owners. The results are incorporated into the Project Justification and Description Report which proceeds to a detailed design and engineering stage, to be conducted on a project-specific basis with the assistance of advisory committees. After design is complete, the final concept for individual projects will be referred to federal agencies that will decide whether it should proceed, be modified, or be abandoned. If the decision is made to proceed, construction of new fish and wildlife habitat in Hamilton Harbour and Cootes Paradise can begin.

1.0 BACKGROUND AND PURPOSE OF THE REPORT

The development of a Hamilton Harbour Remedial Action Plan (RAP) has been underway since 1986. The Hamilton Harbour RAP is intended to be an ecosystem-based blueprint for the restoration of water quality and beneficial uses. The RAP is broad in nature, and is guided by a set of goals which have been developed by a RAP Stakeholders Committee. Two of the goals identified in the RAP address the issue of fish and wildlife:

> "...water quality and fish habitat should be improved to permit an edible, naturally reproducing fishery for warm water species. Water and habitat conditions in Hamilton Harbour should not limit natural reproduction and the edibility of cold water species."
>
> "...healthy and self-sustaining resident and non-resident wildlife populations should be enhanced on a Harbour-wide basis through water quality improvements, habitat rehabilitation and protection".

As the RAP was being developed, it became apparent that despite remedial measures targeted at point and non-point pollution, habitat restoration in Hamilton Harbour and Cootes Paradise will not occur naturally. Direct intervention -- the creation of new habitat and enhancement of existing habitats -- will be necessary to fulfil the above goals. Habitat restoration will provide an improved environment for fish and wildlife, and will also help to improve water quality in the RAP area. Accordingly, one remedial action which has been proposed under the RAP to assist in the fulfilment of the above goals is the Concept Plan for Fish and Wildlife Restoration for Hamilton Harbour.

This report has been prepared, as part of the Hamilton Harbour RAP, by the Fish and Wildlife Restoration Committee for Hamilton Harbour and Cootes Paradise. Its purpose is to outline the Concept Plan for Fish and Wildlife Restoration, how it might be funded, and the history behind its development. It also provides a historical perspective on fish and wildlife populations in the area, along with a description of the existing conditions.

The Concept Plan identifies eight initiatives for restoring fish and wildlife habitat in Hamilton Harbour and Cootes Paradise. It is hoped that this report will promote focused discussion to take place on the Concept and the initiatives. Through a public review process, the Concept will be refined, as outlined in Chapter 5.

1.1 Organization of the Report

Chapter 2 of this report provides a historical perspective on fish and wildlife populations in the Hamilton Harbour Area, along with a description of the setting today. Chapter 2 also includes a detailed description of current habitat in the area, along with information on existing fish and wildlife populations. Chapter 3 outlines how the Concept Plan for Fish and Wildlife Restoration was developed, and details of the Concept itself is presented in Chapter 4. Chapter 5 outlines the next steps in the development of the Fish and Wildlife Habitat Restoration in Hamilton Harbour and Cootes Paradise.

2.0 ENVIRONMENTAL CONDITIONS

2.1 History of Fish and Wildlife in Hamilton Harbour

In the 1800s, Hamilton Harbour was recognized as a unique fish and wildlife habitat that contributed significantly to commercial and recreational fishing, trapping and hunting. The commercial fishery was dominated by lake trout, whitefish, and herring. Kerr and Kerr, the Fisheries Overseers for Hamilton Harbour from 1860 to 1898, reported extensive feeding migrations into the harbour in June and July of lake trout and whitefish. This was followed by migrations in October and November as millions of herring and whitefish entered the harbour to spawn on the rocky shoals along the north shore.

In the 1800s, almost all of Cootes Paradise and the south and west shores of Hamilton Harbour consisted of shallow water marshes that provided spawning, nursery, and adult habitats for the warm water fish community. Pike and bass were the dominant recreational and commercial warm water species. Approximately 12,270 kilograms (kg) of pike were taken by the commercial fishery in 1871 and bass fishing peaked in 1879 with a record catch of 5,400 kg. The diverse warm water fishery included pike, bass, yellow perch, sunfish, muskellunge, walleye, drum, burbot, channel catfish, brown bullhead, and white sucker.

There is little quantitative information on the numbers of wildlife species inhabiting the marshes of Cootes Paradise and Hamilton Harbour before development began in earnest. The information that is available is qualitative in nature and comes mostly from anecdotal writings. Charles Durand wrote that in 1818-19, Cootes Paradise "was a paradise for game of all kinds. Immense flocks of ducks and wildfowl and wild animals innumerable in old times were seen there. It was also the resort of wild fur animals, such as otter, perhaps beaver, fisher, minks, and especially muskrats; snakes were abundant there of all kinds". In 1861, McIlwraith described flocks of waterfowl in Hamilton Harbour "so great as frequently to darken the light of sun by day and make the night hideous with their discordant cries". As late as 1949, Wragg could write of Cootes Paradise, "Judging from reports of its condition, 30 years ago it must have been a remarkable place. In addition to the abundant growth of aquatic plants found there today, wild celery was common and wild rice so abundant that rowing through the marsh, one's boat would be covered with rice. Water was so clean and food so plentiful that ducks remained in thousands until ice formed."

As the population around Hamilton Harbour grew, the impacts on the harbour became greater. By 1900, the cold water fishery was responding to deteriorating water quality, competition from exotic species, exploitation, and habitat loss associated with urban and industrial development. The first collecting sewer for the city of Hamilton was completed in 1854. Prior to this, sewage from 'water closets' was emptied directly into Cootes Paradise and Hamilton Harbour. The combination of low dissolved oxygen, increased ammonia, acute toxicity of bottom sediments to important benthic species, spills of toxic substances in the littoral (shallow) zone, exploitation and finally competition with invading species were sufficient to drive the cold water fishery to extinction. Commercial catches of lake trout, whitefish, and herring which peaked at 4,500, 13,600 and an impressive 114,000 kg per year respectively in the late 1800s, by 1949 had dwindled to 0, 273, and 70 kg. By 1956, catches of these fish had disappeared completely.

The collapse of the cold water fishery was quickly followed by a rapid decline in warm water fish and wildlife populations. Habitat destruction was undoubtedly the most significant factor affecting near shore fish and wildlife communities that relied on tributary streams and shallow marshes for protection, food

and reproduction. Population growth in Hamilton was accompanied by rapid industrial expansion along the south shore of the harbour. By 1912, the harbour was receiving effluents (metals, nutrients, and organic chemicals including solvents and dyes) from three municipalities, two of Canada's largest steel producers, and textile, rubber, paint, and solvent manufacturers. As a result, littoral areas bore the full impact of municipal and industrial discharges. There are many references in the Kerr diaries documenting fish and wildlife mortality along the south shore.

By 1926, industrial expansion was spreading rapidly along the south shore from west to east. Vast amounts of shallow productive marsh were filled to accommodate roads, piers, railways, and factories. This trend continued in the post war years and by 1959, approximately 22 percent of the open water area in the harbour had been lost to landfilling. Although development along the south shore significantly reduced the open water area (and the retention time of the bay); the most significant impact was the loss of the shallow water marsh habitats that had supported extensive fish and wildlife communities along the south shore. Prior to industrial development, the 49 km south shore was a complex marsh ecosystem colonized by emergent and submerged vegetation. The irregular shoreline was inundated with inlets that in many cases extended more than 1 km inland. Landfilling and shoreline protection works have replaced the marsh shoreline available in 1800.

Today there is no gently sloping littoral zone (less than 2.5 meters deep) remaining along the south shore east of the Lax property. The shoreline consists of sheet steel pilings and concrete breakwaters. Most is dredged to 8 m deep for shipping. Sediments along several locations of the industrial section are heavily contaminated with metals and organics and are acutely toxic to sensitive benthic organisms. The entire south and east shores of Hamilton Harbour have been filled, dredged, or reinforced with concrete and steel to combat erosion. Historically important fish and wildlife habitat cannot be reclaimed at these sites. Efforts to develop marsh and littoral habitats must concentrate on the less degraded sites in Cootes Paradise, Grindstone Creek, and along the north and east shores. Some opportunities for habitat creation also exist in the south west end of the harbour.

The north shore looks very much as it did historically, with the exception of the armoured shoreline which property owners have constructed to prevent erosion from wave action. Unlike the wide, gently sloping band of littoral habitat that characterized the original south shore, the north shore slopes steeply, and has only a narrow ribbon of littoral habitat available for restoration. Because much of the shoreline is reinforced with breakwalls, it offers no energy dampening effects to wind driven waves, and is characteristic of a high wave energy zone. As a result, light penetration in the littoral zone is impaired by high concentrations of resuspended bottom sediments, and there is insufficient light to support macrophyte growth. Aquatic vegetation is sparse (less than 3 plants/m^2) or absent in fifty-five percent of the littoral zone along the north shore.

The Cootes Paradise marsh has also been affected by urban development. Emergent vegetation, once abundant throughout the marsh, declined by 85 percent between 1934 and 1985. Similarly, the distribution, species composition,and abundance of submerged vegetation declined between 1940 to 1970; of the 24 species of submerged and floating macrophytes reported in 1949, only 10 were present in the marsh in 1970. The loss of the extensive marsh in Cootes Paradise is due to the combined effects of high water levels, increased sedimentation, nutrient enrichment and increased levels of suspended solids resulting from the resuspension of bottom sediments due to wind and the foraging activities of carp.

2.2 The Setting Today

2.2.1 General Site Description

Hamilton Harbour (Burlington Bay) is a natural bay located at the western end of Lake Ontario (Figure 2). It is 5,400 hectares (ha) in size with a maximum depth of 22 metres. The harbour is separated from the lake by the Hamilton/Burlington Beach Strip, a bay mouth barrier bar. Exchange of water between the harbour and the lake is accommodated through the Burlington Ship Canal (820m x 88m x 9.5m). At the western end of Hamilton Harbour is a second bay known as Cootes Paradise. Cootes Paradise is itself separated from Hamilton Harbour by a barrier bar known as Burlington Heights. Water is exchanged through an artificial opening, the former Desjardins Canal (15 meters x 4 meters).

The total drainage basin of Hamilton Harbour/Cootes Paradise is 49,400 hectares (Figure 3). Cootes Paradise receives run off from four sub-watersheds for a total catchment area of 29,100 hectares. These include: Spencer Creek (23,100 ha); Borer's Creek (2,703 ha); Chedoke Creek (2,720 ha); and several small streams (567 ha). Cootes Paradise also receives discharges from a combined storm sewer overflow and the Dundas Sewage Treatment Plant (STP). Hamilton Harbour receives run off from three sub-watersheds: Grindstone Creek (8,640 ha); Red Hill Creek (7,190 ha); the Indian Creek/Hager Rambo Diversion Channel (2,226 ha); and urban Hamilton (4,470 ha). In addition to run off from these watersheds, Hamilton Harbour receives the discharge of several combined sewer overflow systems and the effluent of four municipal sewage treatment plants. Of the water entering the Harbour from all sources, on an average day, "natural run off accounts for only 2-19%, sewage treatment plants account for 7-16% and Lake Ontario accounts for 72-87% (water entering the harbour from the Burlington and Hamilton sewage treatment plants comes via Lake Ontario by way of the Regional water supply plants." (RAP 1 P.7)

Approximately 17% (380 hectares) of Hamilton Harbour is shallower than six meters (the littoral zone). However, of this amount, only 90 hectares are currently colonized by aquatic vegetation. The most important shallow water littoral habitat is the mouth of the Grindstone Creek, in the north west corner of the harbour. (RAP 1 P.5)

Cootes Paradise has an open water surface area of approximately 250 hectares, and a mean depth of 0.7 meters. At present, only 15% of the area is colonized by aquatic vegetation. (In 1934, by contrast, 85% of the surface area was colonized by aquatic vegetation).

Hamilton Harbour is surrounded by the Niagara Escarpment which has a moderating influence on the local climate when combined with the effect of Lake Ontario. This accounts for the area lying within two broad overlapping life zones: The Great Lakes-St. Lawrence, and the Carolinian (deciduous) Forest Region. The Carolinian life zone is widespread in the eastern United States but only extends into southern Ontario in an area bordered by Lakes Huron, Ontario, and Erie. Consequently the flora within and surrounding the Harbour and Cootes Paradise reflect elements of both these biomes. Nationally, provincially and regionally significant plant and animal species are present and direct wildlife linkages exist with the Niagara Escarpment, Dundas Valley, Red Hill Creek Valley and Grindstone Creek Valley.

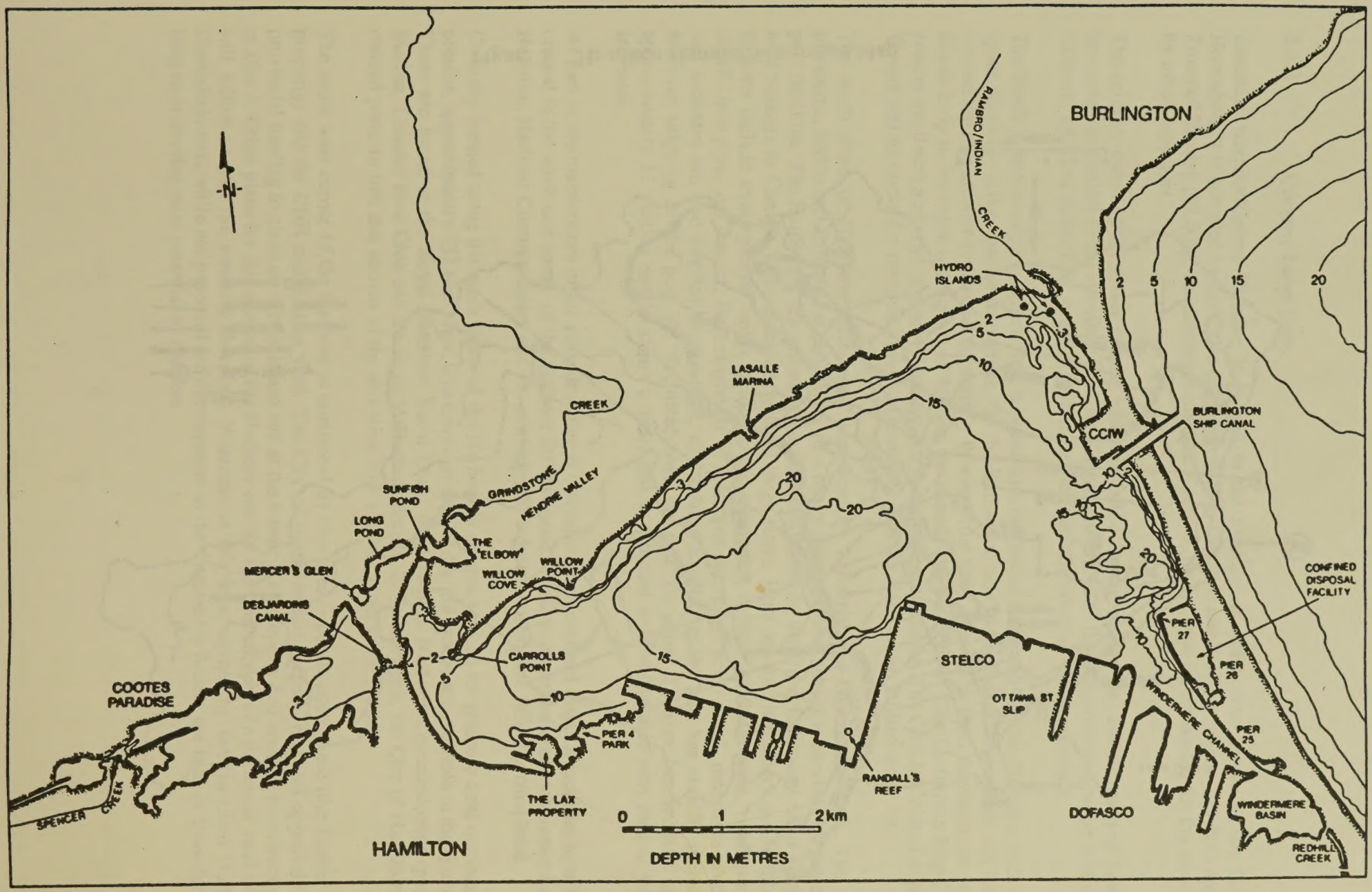


Figure 2. Hamilton Harbour / The Bay Location Map

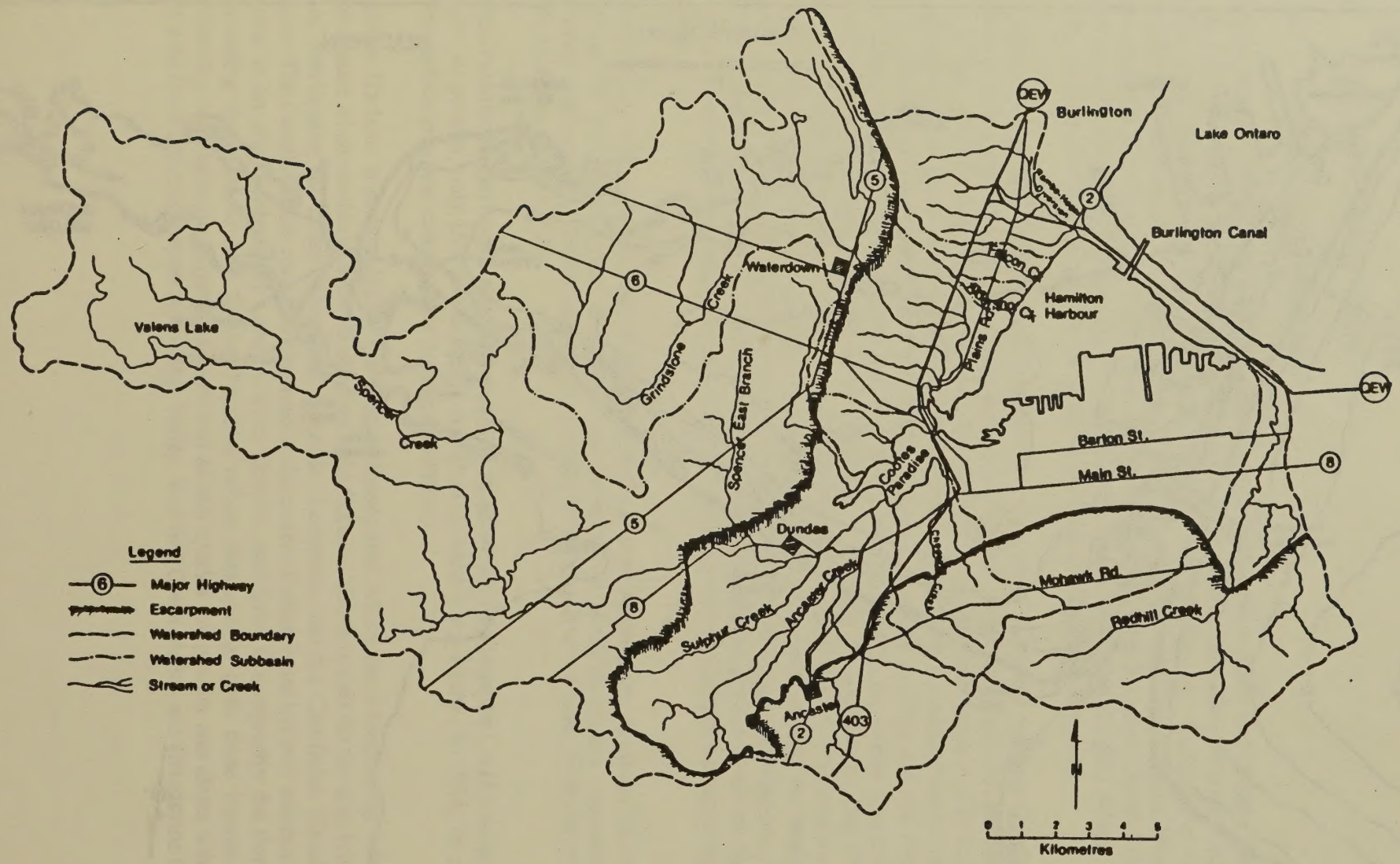


Figure 3. Hamilton Harbour Watershed Map

2.2.2 Current Land Uses

Hamilton Harbour/Cootes Paradise is located in the heart of an urban area known as the Golden Horseshoe. It is bounded by the Cities of Hamilton (pop 360,000),and Burlington (pop 120,000) and the Town of Dundas (20,000). As shown on attached Figure 4, the harbour is surrounded for the most part by urban land uses.

The primary uses of the harbour proper, which include shipping, navigation, and recreational boating, are under the control of the Hamilton Harbour Commissioners. The lands located underwater within the harbour, with few exceptions, are also owned by the Hamilton Harbour Commissioners.

The Beach Strip forming the eastern limit is primarily a residential community within Hamilton with open space along the Lake Ontario waterfront. On the Burlington side of the Beach Strip, plans call for the conversion of a smaller residential community to waterfront open space. The most dominant use on the Beach Strip is the roads and high level bridges associated with the Q.E.W. The Burlington Ship Canal crosses the Beach Strip and connects Hamilton Harbour with Lake Ontario. The Canada Centre for Inland Waters and its docks for research vessels is located within the Harbour on a filled water lot.

The south shore of Hamilton Harbour is dominated by industrial and commercial uses. The steel producers, Stelco and Dofasco, are the focus of a heavy industrial area which is serviced by extensive port facilities. The Harbour is the second largest Canadian Port on the Great Lakes and ranks sixth for total tonnage in Canada. Imports include general cargo, steel, ingot moulds, machinery and fertilizers. Exports include steel, general cargo, beans, grain, newsprint, rubber, synthetic resin, road graders, ductile iron pipe, and cement. Bulk shipments of coal, iron ore, sand, scrap metal, petroleum products and molasses are also handled. Since 1922, the tonnage handled in the port has steadily increased, however shipping in the port has fluctuated over the past 10 years. Tonnage has levelled off at approximately 11 million metric tonnes a year, and is expected to remain stable with modest yearly increases.

As part of the maintenance of the port, dredging is carried out and confined disposal facilities have been created in the south east corner of the Harbour for dredgeate. These containment areas are owned by the Hamilton Harbour Commissioners and are converted to industrial uses once filling is completed.

Centrally located along the south shore of the Harbour is an area utilized for pleasure boat marinas. At present, approximately 737 boat slips, 250 moorings and 70 dry sail spaces are available in the Harbour. These are found at the Royal Hamilton Yacht Club, the Hamilton Harbour Commissioners (public) Marina, Leander Boat Club and the Scott McDonald Marina. In recent years, the City of Hamilton has created plans to link this section of the shoreline with a public open space system.

The south west corner of the Harbour is dominated by two uses -- public open space (the former Lax property) and the CNR marshalling yard. The City of Hamilton has recently received approvals and provincial funding to clean up contaminated soil at the former Lax property and create a waterfront park at Pier 4. Other plans for this section of the Harbour call for the construction of a perimeter road which will follow in part the westerly shoreline. Waterlots in this area, owned by the Hamilton Harbour Commissioners, while not proposed for development in the foreseeable future, are held to allow for the long term development potential of the port.

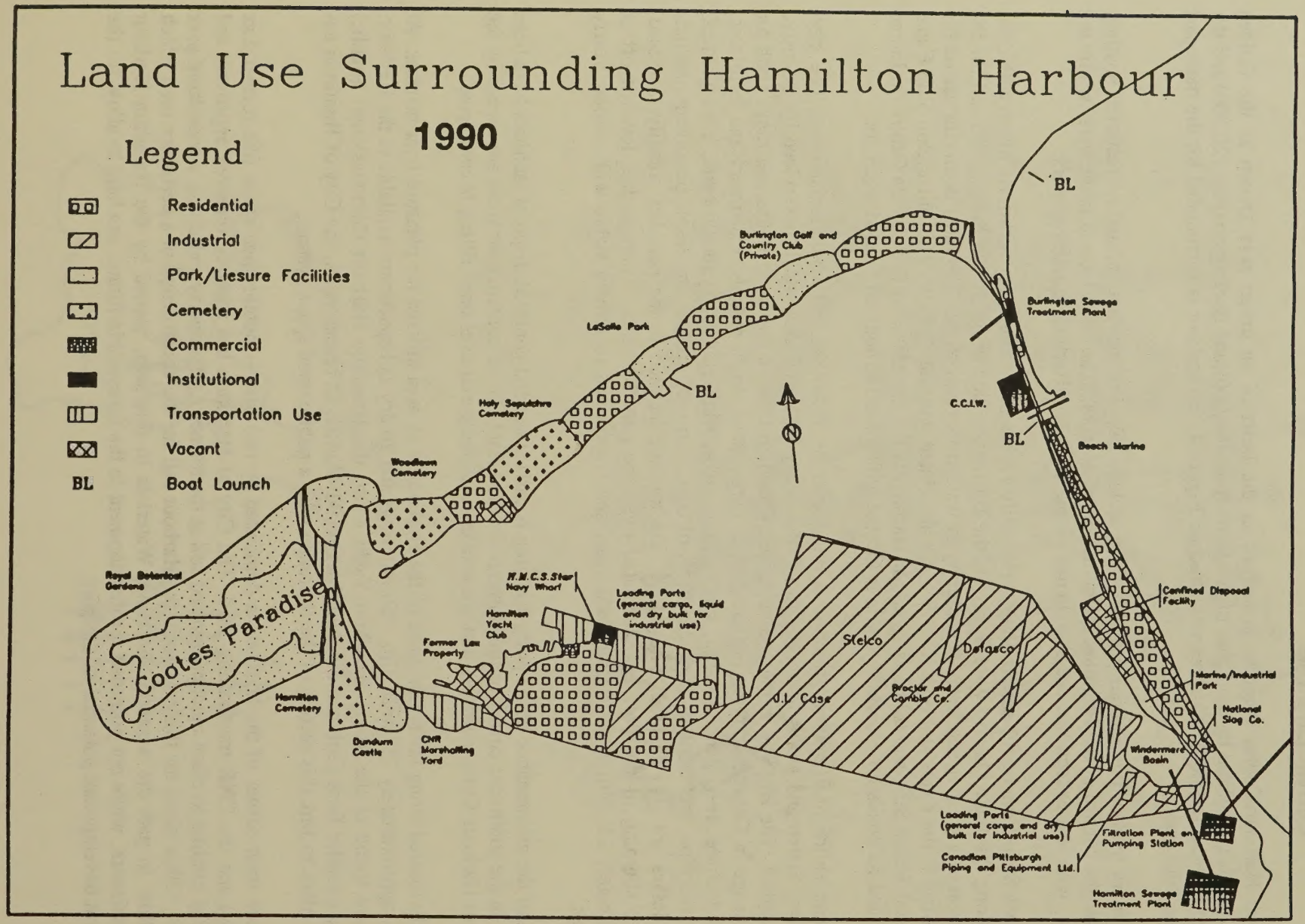


Figure 4. Land Use Surrounding Hamilton Harbour (courtesy of Tim Paterson CCIW)

The westerly shoreline of the Harbour is a height of land separating the Harbour from Cootes Paradise. This area contains several railway lines and is crossed by Hwy 403. Originally designed as a grand entrance to Hamilton, it contains a well developed system of open space, including Dundurn Castle, a historic property owned by the City of Hamilton. The principal land owners in the area are the Royal Botanical Gardens who also own the majority of Cootes Paradise and the mouth of the Grindstone Creek. Cutting through this height of land and linking up Cootes Paradise with the harbour is Desjardins Canal, a long abandoned navigation route to the former port in Dundas.

Cootes Paradise is for the most part contained within an 840 hectare wildlife sanctuary owned by the Royal Botanical Gardens. A residential community abuts the area to the south along with the campus of McMaster University. The north shore is surrounded by an extensive buffer of vacant land and open space. The only proposed land use which may impact on this area is the potential interchange of the harbour perimeter road and Hwy 403.

The north shore of the Harbour is for the most part a residential community with several large pubic and private open space areas. It contains the only section of the shoreline which has not been modified (Carrolls Point to Willow Point). LaSalle Park, centrally located on the north shore, contains a marina and boat launch. The Province of Ontario has recently recommended that a waterfront trail be built along the Lake Ontario Shore from Burlington to Newcastle. It is suggested that in the Hamilton Harbour RAP area, this trail would start at Grindstone Creek and follow the north shore of the Harbour.

2.3 Current Conditions: Habitat, Fish and Wildlife

The following section describes the existing situation in the harbour for habitat, and the existing conditions for fish and wildlife. It has been extracted and consolidated from the Remedial Action Plan for Hamilton Harbour Stage I Report: Environmental Conditions and Problem Definitions, (Sections III.4.5 Macrophytes, III.4.6 Fish, and III.4.7 Wildlife).

2.3.1 Habitat

2.3.1.1 Hamilton Harbour

The composition and abundance of warm water fisheries in Hamilton Harbour is influenced by the type, density, and distribution of submerged and emergent aquatic plants. Apart from an obvious role in sediment stabilization, aquatic vegetation provides essential fish habitat. Fisheries production in the littoral zone appears to be optimum at intermediate plant densities. Sparsely vegetated areas offer little protection from predators while extremely dense vegetation impedes larger predators and reduces feeding success. Plant abundance is influenced by light, water levels, nutrients, substrate characteristics, ice scour, and lake morphometry (Duarte et al., 1986).

The entire 49 km south shore (from Desjardins Canal to the Burlington Canal) was restructured between 1900 and 1985 (Fig. 1) resulting in a loss of 85 percent of the original vegetated shoreline (littoral zone). The loss of the south shore marsh was a major factor contributing to the decline of the warm water fishery, (Whillans, 1979).

The emergent marsh in Grindstone Creek declined from 37.8 ha in 1934 to 5.1 ha in 1985 (Table 1). Most of the loss (32 ha) occurred in the area of the Valley Inn Road. Possible factors responsible for marsh loss include ice scour, damage by carp, siltation, reduced light penetration, and increased water levels. Recent analysis of marsh losses since 1934 show a good correlation with elevated water levels (V. Cairns, DFO, pers. comm.).

The Grindstone Creek marsh is the last remaining stand of emergent vegetation in Hamilton Harbour and the only site suitable for pike reproduction. Eighteen adult pike were observed in the vicinity of the boardwalk marsh in 1985. Only 1 pair were spawning. There was no evidence of pike spawning in Cootes Paradise in 1985 or 1987. (Portt, pers. comm.)

There is insufficient spawning habitat (emergent marsh) in Hamilton Harbour to support a viable pike fishery (20-25 kg/ha). The ratio of spawning habitat to adult habitat is 0.06 in Hamilton Harbour (using 1987 data of 5 ha of suitable spawning habitat in Grindstone Creek and 64 ha of vegetated adult habitat in the Harbour). This is considerably less than the 0.3-0.4 ratio of spawning habitat to adult habitat recommended for productive marshes (Inskip, 1982). Based on these calculations, an additional 19-26 ha of suitable spawning habitat are required to sustain 64 ha of adult pike habitat.

Table 2. Area (ha) of Emergent Vegetation in the Grindstone Creek Marsh from 1934 - 1985.

Year	Valley Inn	Sunfish Pond	Lower Marsh	Boardwalk Marsh
1934	23.0	2.6	6.9	5.3
1939	3.5	2.6	7.9	5.7
1950	1.1	0.1	2.4	3.5
1954	3.0	0.5	1.2	4.2
1959	1.1	2.3	4.9	4.2
1961	0.7	0.9	3.5	5.0
1969	0.6	0.5	1.9	3.8
1972	10.2	0.6	3.4	3.6
1974	0	0.2	0	1.4
1980	0.4	0.4	1.4	3.5
1985	0.4	0.3	0.7	3.7

Source: V. Cairns, GLLFAS, DFO

There are 199 ha of littoral habitat (less than 2 m deep) remaining in Hamilton Harbour. Only 45 percent of the total littoral area contained moderate to dense vegetation. Plant abundance in the remaining 55 percent of the littoral zone ranged from absent to sparse (3 plants/m^2). Submerged vegetation was confined to the north shore and to the west shore of the Harbour between the former Lax property and the Desjardins Canal. Plants did not grow at depths greater than 2.5 m, probably due to poor light penetration below that depth. Plants were absent along the south shore east of the Royal Hamilton Yacht club. The littoral zone along the east shore of the Harbour is shallow enough to permit vegetation but plant growth is limited by almost constant wave action and poor light penetration. Prior to 1985, the east shore, south of the Burlington Canal, was moderately vegetated (V. Cairns, DFO, unpub. data). Shoreline restructuring to accommodate the West Service Road (East Port Drive) transformed this area into a high energy rubble shore that reflects wave action and inhibits plant growth.

With the exception of a small area (16 ha) of dense vegetation in the sheltered LaSalle Marina, the majority of the north shore was moderately vegetated. Plant densities in areas of dense, moderate, and sparse vegetation were 400, 63, and 3 plants/m^2, respectively.

Crowder and Bristow (1986) reported that reduced light transparency was the most important factor limiting the distribution, abundance, and diversity of submerged aquatic plants in the Bay of Quinte. Measurements taken within the protected confines of the LaSalle Marina show increased light penetration

which suggests that the presence of docks and wave barriers provide protection. Not surprisingly, the sheltered area near the marina was also the only habitat in the Harbour characterized by dense vegetation (400 plants/m^2). The increased abundance of plants further dampened the effects of wave action and stabilized bottom sediments. Unprotected littoral habitat on both sides of the sheltered marina had moderate to heavy vegetation.

The source and fate of suspended sediments in Hamilton Harbour are not fully understood. Grindstone Creek, Indian Creek, Cootes Paradise, the STPs, combined sewer overflows, and erosion are obvious sources of suspended sediments to the Harbour. In addition, resuspension of existing sediments in the near shore zone by wave action and possibly by the foraging action of carp also contributes suspended solids to the water column.

Breakwalls have been constructed along more than 5 km of the north shore leaving the area between Carroll's Point and Willow Point as the largest stretch of unprotected shoreline. The banks at this site show signs of recent erosion by wave action confirming its role as a source of sediments to the Harbour. Although erosion along the north shore is minimized by the breakwalls, the restructured concrete shore reflects wave energy back into the littoral zone and increases sediment resuspension. The combination of reduced light penetration and unstable substrate limits plant abundance and distribution. It also reduces the diversity and abundance of benthic invertebrates and fish.

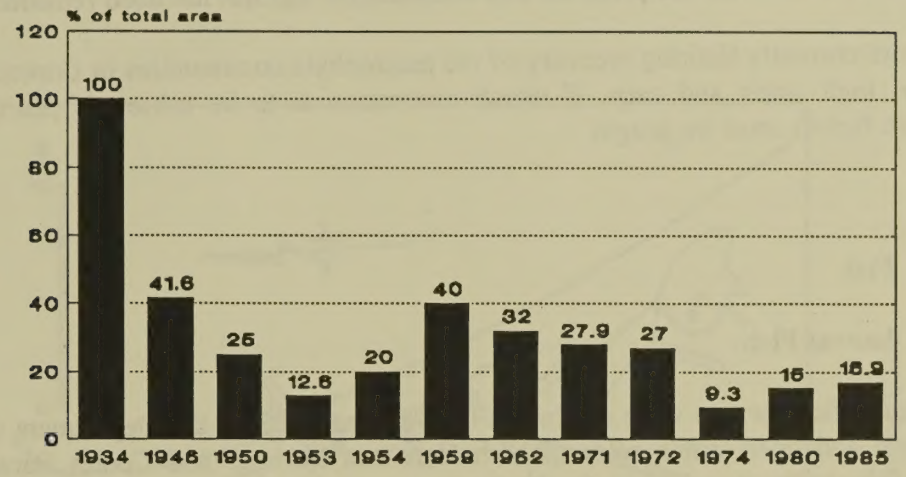
Light penetration is severely limited at the mouth of Grindstone Creek. Secchi depths at this site ranged from 14 to 38 cm throughout the summer of 1985 (Portt, 1986). Suspended sediments frequently exceed 80 mg/l (MOE, 1986b) and appear to be the most important factor limiting light penetration. Suspended clay and silt transported by Grindstone Creek during erosion events is deposited in Sunfish Pond and in the Valley Inn Road area. The mean depth at both sites is now less than 0.5 and 1 m, respectively. The creek, Sunfish Pond, and the estuary are turbid during periods of run off. However, Grindstone Creek is clear during dry periods but Sunfish Pond and the estuary remain turbid.

2.3.1.2 Cootes Paradise

The present marsh flora of Cootes Paradise bears little resemblance to that described in pre-20th century writings. The wetland vegetation of Cootes Paradise and Hendrie Valley/Carroll's Point area is currently dominated by a small number of hardy emergent species such as manna grass (Glyceria, spp.), cattail (Typa spp.) and giant burreed (Sparganium eurycarpum). There are still small localized stands of bulrush (Scirpus spp.) and sedges (Carex spp.) in the more protected inlets which fringe the basin. The present extent of emergent vegetation is approximately 15% of the total area (Figure 5), and is restricted to areas above the normal high water level.

The open water area of Cootes Paradise measures 250 hectares and is virtually devoid of aquatic plants. Around the edges, submergent communities are dominated by a small number of hardy species, for instance, sago pondweed (Potamogeton pectinatus). In 1946-48, 25 species of submerged aquatic plants were found in Cootes Paradise. In 1968-72 and in 1985, 11 species were observed; and in 1987, only 4 species.

Figure 5. Extent of emergent vegatation in Cootes Paradise



Source: V. Cairns, GLLFAS, DFO, and the Royal Botanical Gardens.

Turbidity caused by algal blooms (in response to high nutrient loading) can cause inhibition of submergent plant growth, ultimately resulting in elimination of plant communities. The Dundas STP has been implicated as the primary source of excessive nutrient loadings to Cootes Paradise. It is postulated that the levels of nitrogen and other nutrients, discharged into the marsh, may also have led to the weakening and breaking of stems of some species of emergent macrophytes growing on floating root and rhizome mats (Boar and Crook, 1985). This mechanism can cause widespread loss of macrophyte stands. The extent of the marsh that was floating and therefore possibly affected by high nitrogen loading is unknown.

Turbidity derived from suspended sediments (erosion from urban storm water drainage) reduced light penetration to 14-38 cm throughout the summer of 1985 (Portt, 1986). Silt may also coat leaves, further inhibiting photosynthesis, and may physically damage stems and leaves. High silt loadings can also change substrate texture, rendering it unsuitable for some plant species to colonize. Siltation in Cootes Paradise has changed bottom contours dramatically, resulting in a shallower basin particularly in the eastern portion (Painter et al., 1988). This shallowness has fostered wind-generated resuspension of bottom sediments and therefore has compounded the light penetration problems created by phytoplankton blooms.

A major role in the decline of the Cootes Paradise macrophyte communities must also be attributed to the spawning and feeding activities of carp (Cyprinus carpio) in the marsh. Carp, an introduced species, were implicated by Wragg (1949) as responsible, in part, for the eradication of wild rice and wild celery from Cootes Paradise 30 years before he undertook his studies. Although he did not cite references, Wragg suggested that the apparent failure to re-establish these two plants, circa 1937, was again due to the destructiveness of carp. An ambitious programme of carp control was conducted by the Royal Botanical Gardens in 1952 and again in 1954-56. The latter effort removed 130,000 adult carp and

resulted in dramatic improvement in the distribution and abundance of aquatic vegetation in the marsh (Lamoureux, 1961). However, the program was discontinued and has not been repeated since that time.

The major factors currently limiting recovery of the macrophyte communities in Cootes Paradise appear to be turbidity, high water and carp. If marsh restoration is to be achieved, practical methods of controlling these factors must be sought.

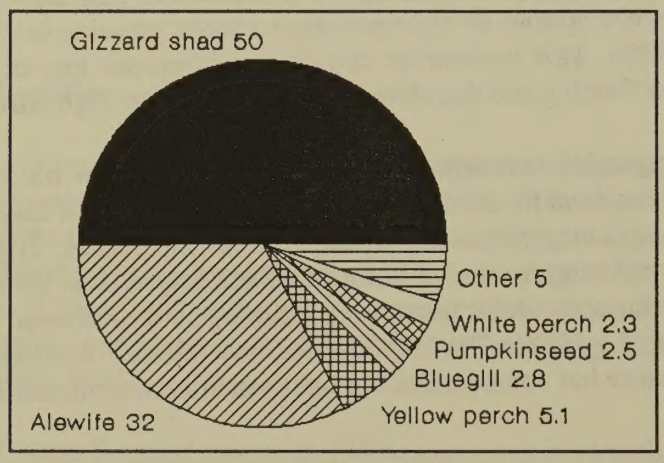
2.3.2 Fish

2.3.2.1 Larval Fish

Larval and juvenile fish surveys were conducted in 1985 and 1987 by the Department of Fisheries and Oceans in littoral and open water areas of both Hamilton Harbour and Cootes Paradise. The most common larval fish are listed in (Figure 6). Of the 42 species of larval fish identified, most species were caught in the west end of the Harbour and in Cootes Paradise (Figure 7).

Twenty-seven adult Northern Pike were observed in Grindstone Creek. Spawning was observed and pre and post-spawning females and males were confirmed. Larval pike were not collected but this is normal since larval pike are particularly difficult to collect.

FIGURE 6. Larval fish composition, 1985 and 1987.
Percent Composition



Source: J. Leslie, DFO

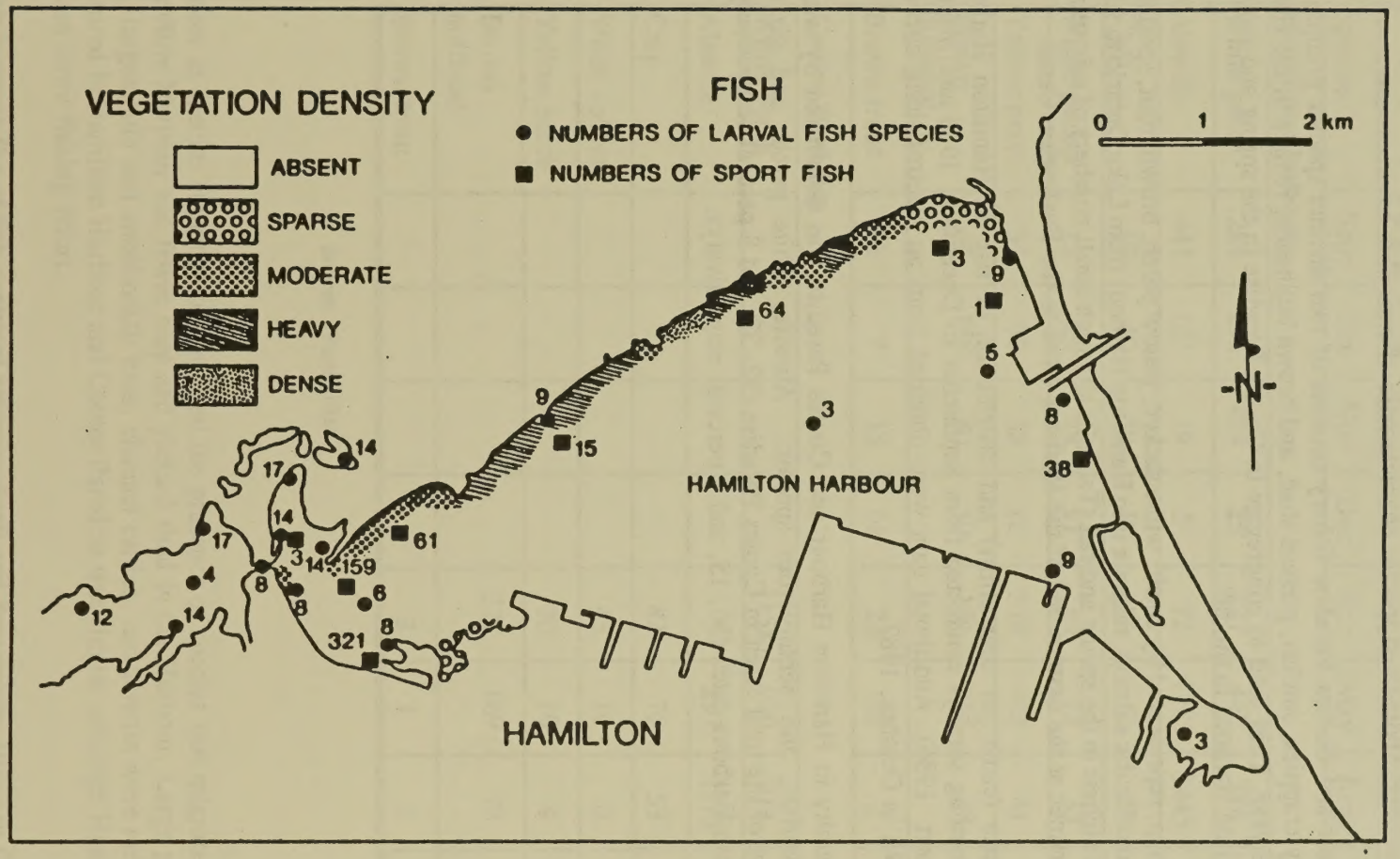


Figure 7. Vegetation Density and Fish Distribution in Hamilton Harbour

2.3.2.2 Adult Fish

Hamilton Harbour supports a diverse fishery represented by 19 families, 42 genera, and 59 species. Although diversity is high, community structure has shifted from the larger, long-lived species common in the late 1800s to smaller, short-lived species characteristic of eutrophic environments.

The Hamilton Harbour and Cootes Paradise fishery consists of two distinct species groups. The first group, represented by crappies, sunfish, gizzard shad, and brown bullheads, remain in the Harbour and marsh throughout the year. They tend to congregate in Cootes Paradise in the spring and move into the western end of Hamilton Harbour in the fall.

The second major group, represented by smelt, white sucker, yellow perch, brown trout, spottail shiners, herring, lake chubs, and Pacific salmon, migrate into Hamilton Harbour from Lake Ontario to feed and/or spawn. Abundance is highest in the spring and fall (Table 2) although small numbers of migrating species were found in the summer at the eastern end of the Harbour close to the Burlington Canal.

The relative abundance (catch per unit effort) and distribution of fish in Hamilton Harbour were determined from gillnetting surveys conducted from September to December, 1984 and from April to September, 1985 (Portt, 1986). Additional data were obtained from an electrofishing survey of the Harbour by the OMNR in October, 1987.

The 1985 fish community in Hamilton Harbour and Cootes Paradise was dominated by warm water planktivorous, herbivorous, and benthivorous species. Alewife, white perch, and gizzard shad represented 92 percent of the total catch in Cootes Paradise (52, 32, and 8 percent respectively) and 71 percent of the Hamilton Harbour catch (56, 15, and 1 percent, respectively).

Table 3. Seasonal changes in the numbers of fish caught in index gillnets in Hamilton Harbour from September 1984 to August 1985, and Cootes Paradise from April to August 1985.

	1984				1985				
Species	Sept	Oct	Nov	Dec	Apr	May	June	July	Aug
Hamilton Harbour									
White perch	284	293	414	25	227	447	356	556	513
Alewife	441	101	19	5	72	1285	3445	832	499
Carp	19	40	58	9	3	7	20	23	27
White sucker	15	29	28	37	67	73	33	33	20
Yellow perch	39	93	38	12	219	445	41	3	33
Brown bullhead	69	158	80	30	151	255	88	80	48
Brown trout	3	7	15	14	28	28	2	5	1
Cootes Paradise									
White perch					1158	929	911	608	1038
Alewife					5	297	3273	3350	184
Carp					82	76	53	86	64
White sucker					45	19	0	0	0
Yellow perch					80	10	4	2	10
Brown bullhead					271	169	78	67	98
Brown trout					3	1	2	0	2

Source: Portt, 1986

Differences in species composition reflected the presence of species that migrate between Lake Ontario and Hamilton Harbour and fewer carp and gizzard shad in the Harbour. Large piscivores such as pike, garpike, largemouth and smallmouth bass, channel catfish, and bowfin were rare. The total number of fish captured in Hamilton Harbour and Cootes Paradise was similar although Hamilton Harbour received 30 percent more fishing effort.

Total fish biomass (kg of fish captured between April and September, 1985) in Cootes Paradise was 1.5 times greater than that in Hamilton Harbour. Ninety-four percent of the fish biomass in Cootes Paradise

was contributed by carp, gizzard shad, white perch, alewife, and brown bullhead. These species contributed only 60 percent of the total biomass in Hamilton Harbour. Apart from fewer gizzard shad and carp in the Harbour, the most significant difference between the two sites was the contribution of other species to the total biomass. Thirty-two percent of the Hamilton Harbour biomass represented Lake Ontario species migrating into the Harbour. The largest contributors included white suckers, yellow perch, brown trout, spottail shiners, and American smelt (10, 9.2, 7.3, 3.6, and 2.4 percent of the total biomass respectively). The remaining 21 species contributed only 2.5 percent of the fish biomass in the Harbour.

2.3.2.3 Contaminant Levels in Fish

While fish from Hamilton Harbour have accumulated trace organics, it can be said that the levels in edible portions (muscle) have declined steadily between 1972 and 1981. Until 1985, sport fish collected from Hamilton Harbour for contaminant analysis had usually been limited sample size. In 1985, large collections were obtained, and analyses were completed for most of the parameters specified. Review of these results enabled the consumption advice contained in the annual Guide to Eating Ontario Sport Fish to be upgraded (MOE, 1988a).

Five of the twelve species listed in the Guide have limitations on consumption of some sizes of those fish. One species is advised for restricted consumption of all sizes sampled, and seven species have no advised consumption limitations.

Consumption limitations arise from the presence of one or more of three contaminants: mercury, PCBs, and Mirex. Mercury levels in the edible portion of freshwater drum (sheepshead) were found to average 0.56 mg/kg (range 0.16 to 1.2). Statistical projection indicates that this species would exceed 0.5 mg/kg mercury in the 35 to 45 cm size range, and 1.0 mg/kg mercury in the 45 to 55 cm size range. Assessment of the organic contaminant data for this species showed Mirex levels exceeded the 0.1 mg/kg Federal guideline in the 45 to 55 cm size range of fish in this sample, resulting in further advised restrictions on the consumption of large freshwater drum.

In white perch, both PCB and Mirex were found to exceed the respective Federal guidelines of 2.0 mg/kg PCB and 0.1 mg/kg Mirex in the 25 to 30 cm length range. Mercury was calculated to exceed the 0.5 mg/kg guideline in the 30 to 35 cm size range, however this exceedence is over-ridden by the exceedences for PCB and Mirex.

Carp over 65 cm in length are advised for restricted consumption based on the projection that PCBs will exceed 2.0 mg/kg in specimens of this size.

While the sample of channel catfish was small, the PCB and Mirex levels in nearly all individuals exceeded the Federal guidelines. For this reason, all sizes of channel catfish from Hamilton Harbour are advised for restricted consumption only. This includes specimens in the length range from 20 to 65 cm.

Few brown trout were collected, and most of them exceeded the Federal guideline for Mirex. Calculations indicated that brown trout from 45 to 65 cm would exceed 0.1 mg/kg Mirex. Brown trout in the size range collected were calculated not to exceed the 2.0 mg/kg PCB or 0.5 mg/kg mercury guidelines.

The other seven species (rainbow smelt, brown bullhead, northern pike, black crappie, white sucker, yellow perch, and white bass) are considered suitable for consumption in regard to Federal guidelines for mercury, PCB, Mirex and DDT.

More recent data were collected in 1987 by the Department of Fisheries and Oceans. Composite whole fish samples of carp, white perch, brown bullheads, and white suckers (two pooled samples of 10 large and 10 small fish of each species) were analyzed in 1987. The results indicate that carp and white perch in Hamilton Harbour are accumulating PCBs. Concentrations of Mirex, DDT, DDE, HCB, Chlordane, Dieldrin, and Endrin were below consumption advisory levels. PCB accumulation in carp occurs at several other sites on Lake Ontario and consumption advisories (based on PCB's, Mirex and pesticides) are in effect at five of the nine sites sampled in Lake Ontario and the St. Lawrence River (MOE, 1988a).

Determining the source of the contaminants that accumulate in Hamilton Harbour fish is complicated by seasonal movements between the Harbour and the lake. At least 15 species, including Pacific salmon, lake trout, rainbow trout, brown trout, white perch, white suckers, yellow perch, American smelt, white bass, freshwater drum and carp, migrate into the Harbour and Cootes Paradise from Lake Ontario. Some species, such as carp and white perch, remain in the Harbour (and Cootes) from May-November and contaminant burdens during this period of maximum feeding are strongly influenced by local conditions. Trout and salmon enter the Harbour for short periods in the spring and fall and contaminant burdens in these species are more representative of Lake Ontario exposure. Consumption advisories for salmon and trout are in effect at most sites on Lake Ontario.

Studies of blood lead levels have demonstrated little difference between Hamilton Harbour fish and those from other parts of the Great Lakes. In fact, fish from Toronto Harbour and other Lake Ontario locations were more contaminated. This was true even for benthic feeding species which generally accumulate more lead than pelagic feeders.

Tissue levels of PCBs and other organochlorines in white suckers from Hamilton Harbour were similar to levels in suckers from several sites along the north shore of Lake Ontario. This data suggest that contaminants in Hamilton Harbour fish, particularly non-resident species, are strongly influenced by Lake Ontario. Tissue burdens in non-migratory Harbour predators such as pike and bass are also affected by Lake Ontario contaminants. Migrating alewife, smelt, white perch, and yellow perch, are important food for resident fish. Hurley (1986) reported that these species constituted 76 percent of the northern pike diet in the Bay of Quinte.

2.3.3 Wildlife

Geographically the Cootes Paradise/Hamilton Harbour area lies within two broad and overlapping life zones: the Great Lakes-St. Lawrence and the Carolinian. Consequently, the flora and the fauna reflect elements of both of these major biomes.

The RAP Stakeholders have identified the open water area of Hamilton Harbour and five shoreline areas within the basin as having significant wildlife associations and therefore requiring protection/enhancement in the RAP (Hamilton Harbour Stakeholders, 1986). The current status of the wildlife communities is discussed below in detail for each sub-area within the Harbour.

2.3.3.1 Physical Descriptions of Habitat Sub-Areas

Cootes Paradise: Cootes Paradise is an 840 hectare wildlife sanctuary located at the extreme western end of Hamilton Harbour. The sanctuary is managed and almost wholly owned by the Royal Botanical Gardens. It has been classified by the Ontario Ministry of Natural Resources as a Class 1 wetland (MNR, 1987) and an Area of Natural and Scientific Interest (ANSI). It has been designated as an Environmentally Sensitive Area (ESA) by the Regional Municipality of Hamilton-Wentworth. The Canadian Wildlife Service (CWS) has described Cootes Paradise as an important waterfowl staging area in Lake Ontario (Dennis et al., 1984).

Cootes Paradise is comprised of roughly 70% terrestrial upland habitat and 30% wetland habitat. The vegetation of the uplands is primarily climax forest with maple and oak predominating. Marsh vegetation comprises approximately 12% of the total wetland area, the remainder being open water. The shoreline is deeply indented, particularly on the south shore where numerous wooded ravines terminate in small coves or inlets. There are four major hydraulic inputs (Hopkins Creek, Chedoke Creek, Spencer Creek, and the town of Dundas STP).

Hendrie Valley/Carroll's Point: Hendrie Valley/Carroll's Point is an area of approximately 150 ha located in the lower reaches of Grindstone Creek. The creek is a major watercourse whose headwaters originate above the escarpment in Flamborough and flow south from Waterdown. The Royal Botanical Gardens owns and manages the area, including the Carroll's Point water lot. This area has been designated an ESA in Halton Region. The vegetation is mixed deciduous forest on the slopes, with a small portion of open wet meadow and marshy bottomland where several small ponds vegetated with cattail and manna grass are located.

Pier 27: Pier 27 is a man-made area of approximately 28 hectares in the southeast corner of Hamilton Harbour currently utilized for contaminated Harbour dredgate disposal by the Hamilton Harbour Commission. It is composed of two large ponds surrounded by rubble berms, and is gradually being filled with dredgate. The berm at the less disturbed north end is vegetated with shrub willows (Salix sp.) and young eastern cottonwood trees (Populus deltoides). This area has been designated an ESA in Hamilton-Wentworth Region.

Hydro Islands: The Hydro Islands are located in the northeast corner of Hamilton Harbour and consist of two stone islands once constructed to provide foundation for large hydro transmission towers. The towers have been removed from the islands. The islands provide breeding habitat for a large colony of Common Tern. The Hydro Islands have been designated an ESA in the Hamilton-Wentworth Region.

Windermere Basin: Windermere Basin is a 40 hectare, shallow (0.7-1.0 m) water basin, located at the southeast corner of the Harbour. It receives hydraulic inputs from Red Hill Creek, Stelco, and the Hamilton STP.

Van Wagner's Ponds: The area known locally as the Van Wagner's Ponds (or Van Wagner's Marsh) is a significant natural wetland in the Hamilton area. It includes the marsh area near the mouth of Red Hill Creek on the south side of the QEW, and the two ponds on the north side of the QEW, and is one of few remnants of the once extensive shoreline marshes of Lake Ontario.

2.3.3.2 Birds

Cootes Paradise: Although detailed information exists at the Royal Botanical Gardens for terrestrial bird species, the present discussion is confined to waterbirds. It is sufficient to point out that breeding bird densities and species diversity are higher in the terrestrial habitats of the north shore when compared with those of the wetland habitats.

The marshes that border the west end of Cootes Paradise contain breeding rails, coots and marsh wrens in small numbers, and some species which breed rarely in this region. West Pond is also frequented by several species of dabbling ducks, principally, American black duck (Anas rubripes), common merganser (Mergus merganser), and in the deeper canal, hooded merganser (Lophodytes cucullatus) during migration. There is also some evidence that wood ducks, (Aix sponsa) blue-winged teal (Anas discors) and Canada geese (Branta canadensis) still breed in this area in small numbers and in 1977 the last known breeding attempt of the black tern (Chlidonias niger) reportedly occurred here. Herons and egrets regularly feed in West Pond. The remnant marsh which borders the south side of Spencer Creek willow line still provides breeding habitat for small numbers of bitterns, rails and marsh wrens. A small pond formed by a break in marsh vegetation contains concentrations of waterfowl especially during spring migration, and affords good feeding areas for herons particularly the black-crowned night heron, (Nycticorax nycticorax).

On the north side of the Spencer Creek willow line, heavy autumn concentrations of dabbling ducks, principally, green-winged teal, (Anas crecca), mallard (A. platyrhynchos), gadwall (A. strepera) and wood duck occur. In addition osprey (Pandion haliaetus), herons and egrets are frequently seen feeding during migration.

At the end of the willow line, during low water years, an extensive mudflat is created. During 1984/85 a total of 27 species of shorebirds were recorded. This is considered one of the best areas in southern Ontario to observe shorebirds in the fall. In addition, it is an excellent feeding area for herons, egrets and all species of dabbling ducks, especially green-winged teal and northern pintail (A. acuta). The mudflats are also known for large concentrations of loafing terns and gulls. Seven species of the latter were recorded in 1984/85.

The central open water area of Cootes Paradise is principally used by migratory ducks, especially diving ducks. This is the only area in Cootes Paradise where common loons, (Gavia immer), red-necked grebes (Podiceps grisegena) and horned grebes (P. auritus) have been recorded. During the fall and early winter, large numbers of common mergansers are observed feeding in this area until Cootes freezes. The old Desjardins Canal pilings provide an important preening location for double-crested cormorant (Phalacrocorax auritus), common terns (Sterna hirundo), herring gulls (Larus argentatus) and great black-backed gulls (Larus marinus).

The aquatic areas at Princess Point/Chedoke Creek mouth are important waterbird concentration areas. In early spring, open water attracts early migrant waterfowl. In the fall, when water levels are lower, there are large numbers of dabbling ducks, especially gadwall and American black duck. As well, gulls and a variable number of Canada geese congregate during the fall.

There are a number of smaller remnant marshes which rim Cootes Paradise shoreline and they provide limited breeding habitat for a small number of regionally rare species such as the sora rail (Porzana

carolina) and least bittern (Ixobrychus exilis).

Hendrie Valley/Carroll's Point: Waterbird usage of this area has three principal concentration points. A small patch of cattail near the Desjardins Canal supported two species of breeding birds in 1984: the mute swan (Cygnus olor) and common moorhen (Gallinula chloropus). Both species are rare in the region. The open water in Carroll's Point bay is heavily utilized by nesting and migrating waterfowl. Diving ducks are very common here during spring and fall. During the winter, loafing gulls, particularly greater black-backed gull, and glaucous gull (Larus hyperboreus) are associated with this area. At the mouth of Grindstone Creek, when low autumn water levels expose mudflats, many species of shorebirds, such as the common snipe (Capella gallinago), congregate. This area is heavily utilized for feeding by black-crowned night heron, osprey, and dabbling ducks, particularly gadwall.

Pier 27: The most outstanding feature of this area is the density and diversity of nesting colonial birds. The cottonwood trees provide nesting sites for a large colony of black-crowned night herons. The night heron colony has been expanding steadily since 1975 when six nests were discovered (North, 1975). In 1987, the colony contained 212 active nests. The first cormorant nest was found on the ground in 1984. Since 1985, they have increased dramatically in the cottonwood trees to 51 nests in 1987. The first nesting of the snowy egret (Egretta thula) in Canada occurred here in 1986 (Curry and Bryant, 1987).

The berms and filled cells of the containment area support a large ring-billed gull (Larus delawarensis) colony, which numbered over 21,000 nests in 1987. This is one of the largest gull colonies on the lower Great Lakes. About 200 herring gull nests, 150 common tern nests and 134 Caspian tern (Sterna caspia) nests are located around the gull colony. The nesting of common terns is regionally significant. The Caspian tern is considered to be a rare species in Ontario and Canada (Cadman et al., 1987).

Other species which nest on the berms around the ponds are Canada goose, mallard, gadwall, spotted sandpiper (Actitus macularia) and killdeer (Charadrius vociferus). Species which have nested in the past include green-winged teal, marsh wren (Tetmatodytes palustris), common moorhen and American coot (Fulica americana); all of which are regionally significant breeding species.

The ponds are used for staging by large numbers of migratory waterfowl in the autumn. Many species of shorebirds feed at the mudflats along the shores of the ponds during late summer and autumn, including several species rare to Ontario, such as the American avocet (Recurvirostra americana) and willets (Catoptrophorus semipalmatus) in 1987 (Jennings, 1987).

Hydro Islands: Members of the Ontario Bird Banding Association banded 552 nesting terns and counted over 200 nests from these two small islands in 1985. During the late summer and early fall double-crested cormorants use the islands for resting and preening.

Windermere Basin: Local naturalists know this area to be regionally significant for waterfowl during the autumn and winter. Waterbird surveys of the Basin were conducted by CWS in the autumn of 1986. The average number of birds present per count was 1867, with the most numerous species being Scaup (Aythya sp.), American black duck, mallard, and bufflehead (Bucephala albeola) (Dobos and Weseloh, 1987). Average numbers of waterbirds during winter surveys increased to 4,648 birds per count. Regionally significant species of waterfowl, which overwintered at the Basin, include green-winged teal, northern pintail, northern shoveler (Anas clypeata), redhead (Aythya americana), hooded merganser and ruddy duck (Oxyura jamaicensis).

During low water periods in the late summer and autumn, migrating shorebirds including species rare in Ontario are attracted to the exposed sludge bank in large numbers. Recent rare sightings include a piping plover (Charadrius melodus) (Jennings, 1986a), an endangered species, and an American oystercatcher (Haematopus palliatus) only the second ever recorded in Ontario, (Jennings, 1986b).

Areas of marsh vegetation along the shore of Windermere Basin are the only remnants of the once extensive marshes of Hamilton Harbour. These areas provide nesting habitats for several bird species including mallard, gadwall, American black duck, green-winged teal, and common moorhen. At least 30 broods of waterfowl were observed there during the summer of 1987.

Van Wagner's Ponds: This area has substantial areas of emergent aquatic vegetation (mostly cattail) which provide nesting habitat for a number of regionally significant bird species. It also has extensive submergent aquatic vegetation (pondweed and water lilies) which provides food for a large number of waterbird species.
(Dredging, filling and resculpturing the basin and shoreline in 1990 have altered this habitat and the composition of species which utilize Windermere Basin.)

The black tern, a provincially rare breeding species, has nested here for many years. Since 1978, this area has been the only nesting site in the region. The last recorded nests were in 1986. The least bittern, another provincially rare breeding species, has also nested here in recent years. This area is one of two regional breeding sites. The green-backed heron, common moorhen and pied-billed grebe, all regionally significant breeding species, have nested at Van Wagner's Ponds. Other marsh birds regularly use the area as a feeding site, such as great blue heron, great egret, black-crowned night heron, Virginia rail, sora rail, American coot, Caspian tern, common tern, belted kingfisher, and marsh wren. Some of the rare marsh birds seen here include eared grebe, snowy egret and Forster's tern.

The Van Wagner's Ponds are an important staging area for migratory shorebirds and waterfowl. During periods of low water levels, exposed mudflats attract at least 25 species of shorebirds, including rare species such as willet, Hudsonian godwit, western sandpiper, and piping plover (an endangered species). Waterfowl which regularly use the ponds include all of the regular puddle duck species, plus redhead, lesser scaup, and hooded merganser.

The Van Wagner's Ponds area is a migration point for landbirds as well. This area provides an island of habitat for birds which migrate along the shore of Lake Ontario. Several rare species, including bald eagle, merlin, peregrine falcon, little gull, yellow-billed cuckoo, snowy owl, black-backed woodpecker and western kingbird, have been observed there. The terrestrial habitat around the ponds also provides breeding habitat for many common species of birds.

Hamilton Harbour: Hamilton Harbour proper has a diverse and abundant waterbird population associated with it. CWS waterbird surveys in the autumns of 1985 and 1986 recorded approximately 1200 birds per count composed of up to 43 species (Dobos and Weseloh, 1987). Birds were generally concentrated in groups at specific locations around the Harbour. The LaSalle Park Marina, the Hamilton marinas, and the northeast shoreline areas had the greatest numbers of birds per survey. The western end, Lax landfill, LaSalle Park Marina and the northeast shoreline areas had the greatest number of species of waterbirds. The steel factory shoreline, the centre of the Harbour, the Burlington residential shoreline, and the highway and railway shorelines had the fewest numbers and species.

One of the best spring and fall concentrations of waterfowl is located directly below the Woodland Cemetery near the northwest shore. Here can be seen scoters (Melanitta sp.), tundra swans (Olor columbianus) and mergansers.

Contaminants in Birds

The earliest studies of contaminants in birds from Hamilton Harbour date from 1970 when Gilbertson and Reynolds (1972) reported HCB, dieldrin, DDE and PCBs in common tern (Sterna hirundo) eggs from the Hydro Islands. This was the first reported instance of HCB in avian tissue. In 1971, Gilbertson (1974) conducted further investigations which showed that the terns which nested on the Hydro Islands returned in the spring relatively free of contaminants but the residue levels in their eggs increased with later dates of laying. Eggs laid in June had higher contaminant burdens than those laid in May. He also discovered deformities, suspected of having been mediated by contaminants, among terns nesting on those islands (Gilbertson et al., 1976).

Few studies were conducted within the Harbour itself during the remainder of the 1970s. Herring gull eggs from the Harbour were sampled in 1981, 1982, 1984 and 1986. In 1981, DDE, PCBs and Mirex levels were 11, 79 and 1.9 mg/kg (wet weight), respectively, whereas in 1986, those same contaminants were 4.0, 25 and 0.71 mg/kg, a reduction of 63 - 68% (CWS, data files).

In 1981/82, a Lake Ontario-wide survey was done of contaminant levels in herring gull eggs. Eggs from 8 Lake Ontario sites, including Hamilton Harbour, showed no significant variation in contaminant levels among sites (except for one compound at one site), (Weseloh and Struger, 1985). In other words, contaminant levels in herring gull eggs from Hamilton Harbour were neither significantly higher nor lower than those from other Lake Ontario sites. In a 1983 study of lead, cadmium and mercury levels in herring gulls from four Great Lakes sites, adult gulls from the eastern Harbour had the highest levels in 25% of the cases. Kidney levels of lead and cadmium were 6.90 and 2.16 mg/kg (wet weight), respectively, and liver levels of mercury were 1.36 mg/kg. Eggs and young of herring gulls nesting at Pier 27 had elevated levels of both organics and heavy metals, when compared to Great Lakes samples (CWS, data files; Struger et al., 1987).

It is paradoxical that some populations of water birds congregate in the east end of Hamilton Harbour where the sediments are known to be contaminated with organics and heavy metals, and the habitat has deteriorated to a point where it is substandard at best. Many birds breed in the area during the spring and are attracted to the area for migrational staging and overwintering. Wildlife in this area has been shown to accumulate high levels of contaminants and to suffer significant health problems. Many of the birds ingest highly contaminated food. In a 1986 study, flightless domestic ducks were released into Windermere Basin and two other sites. Those at Windermere accumulated PCB residues almost 50 times greater than ducks at the other locations. Lead levels were also greatly elevated in Windermere Basin birds compared to those from the other sites. There are strong suggestions that lead was the prime causative factor in the die-offs of both the domestic ducks and an earlier case involving wild ducks at Windermere (CWS and MOE, unpub. data). This area produces or has the potential to produce contaminated birds and other wildlife, and this condition could not be allowed to persist. For this and other reasons, the Windermere Basin sediments have been dredged and are confined behind berms along the shores on either side of the remaining channel. With the completion of the sediment remedial work in Windermere Basin in 1991, follow-up work will be required to confirm its efficacy.

Recently, young and adult mallard ducks from Hamilton Harbour were surveyed for contaminants in 1988 by the Ontario Ministry of Natural Resources (Glooschenko et al, 1989). Analyses included octachlorostyrene, 7 PCB congeners, hexachlorobenzene and pentachlorostyrene. Liver and muscle tissues were both investigated and data from 5 sites around the Great Lakes were compared. The specific site from which the Hamilton Harbour ducks were taken was Windermere Basin. The data of greatest concern were PCB data for the Windermere Basin ducks. PCB congeners 138, 153, and 180 were significantly higher (up to 433 ppb in liver) for Hamilton Harbour mallards than any other area (Welland R., Amherst Is., Detroit R., and Cornwall Is.). While no statement has been issued in Canada regarding acceptable daily intake levels of PCBs in waterfowl at this time, the levels are a concern.

Despite these findings, the recent breeding success of several colonies of fish-eating birds in the Harbour, including common terns, is cause for guarded optimism. It should also be noted that levels in gulls probably represent the integration of levels in food from distances within 5 - 10 miles from the colony site. Thus levels in Hamilton Harbour gulls are not indicative of only Hamilton Harbour.

Specific Concerns for Bird Populations

Migratory bird species, in addition to being exposed to the cumulative effects of contaminants, must cope with a dwindling but vital food supply during migration. Surveys by CWS indicate that the remaining marshes along the Lake Ontario shoreline are extremely valuable as waterfowl concentration areas in spring and fall (Dennis and Chandler, 1974). Therefore, any efforts to expand food production in the remaining marshes will have a beneficial effect on waterbirds and other birds, and wildlife. Some adaptable birds, mainly scavengers, have benefitted from habitat alterations, and now numerically dominate the resident wildlife community structure.

The major concerns for wildlife in the eastern Harbour area are: 1) the occurrence of heavy metals and toxic organics in the surficial sediments of the Harbour, and in the confined disposal facilities of the Hamilton Harbour Commission; 2) the impact of these contaminated sediments upon wildlife; 3) the future development plans (resulting in habitat loss) for Windermere Basin and areas known locally as the Hydro Islands, Pier 27 and the confined Disposal Facilities.

Dredging of Windermere Basin in 1988 was carried out to remove severely contaminated sediment. At Pier 27, property owned by the Hamilton Harbour Commissioners, the future is not yet assured. The Commissioners have said that they have no plans for the area for the immediate future, (that is for the next 10 to 15 years). However, eventually they may want to put warehouse facilities, or some similar development, on the site. That development would displace the nesting colony of some 25,000 pairs of gulls, terns, herons and cormorants which currently breed there. The question is, given the long lead time before development is to take place, could the birds be encouraged to move to some other nearby, man-made or natural, nesting area? And if so, where, when and how? Less desirable species, like ring-billed gulls, will almost certainly move with little or no problem. However, for other species which are more sensitive to disturbance, for example Caspian terns, there is no known precedent for "moving" them from one site to another.

2.3.3.3 Reptiles and Amphibians (Herpetiles)

Cootes Paradise: Significant concentrations of frogs and turtle species still occur in many localized wetland habitats. Frogs are especially abundant wherever vegetation remains flooded throughout spring and fall. The northern leopard frog (Rana pipiens) and American toad (Bufo americanus) are the most common species and are well distributed in all marshy areas, but are especially abundant in the old Spencer Creek bed. The green frog (Rana clamitans melanota) also occurs here. The western chorus frog (Pseudacris triseriata) is uncommon and found in small patches of marsh vegetation.

Turtle populations in Cootes Paradise are high in species diversity and abundance. The preferred areas of concentration are those which provide good basking sites and readily available food such as in the old Spencer Creek bed, Westdale Inlet and backwater ponds at the extreme western end. One of the latter ponds rivals other sites in North America as the highest estimated density of the midland painted turtle (Chrysemys picta marginata). Similarly, densities of snapping turtles (Chelydra serpentina) in the western end of Cootes are considered very high when compared to other sites, especially during breeding season in early June, when many females seek a suitable substrate for egg laying. The shoreline in this area provides good opportunities for this activity, and it is likely that the largest segment of the population in the western end resides there. Small populations of turtles such as Blanding's (Emydoidea blandings), found only in the old Spencer Creek bed, have quite restricted distribution, while a regionally uncommon species of the map turtle (Graptemys geographica) occurs in fair (20-30) numbers in Westdale Inlet.

Hendrie Valley/Carroll's Point: Reptile and amphibian populations of the area are characterized by species which are local or regionally significant. For example, both bullfrog (Rana catesbeiana) and pickerel frog (R. palustris) still occur in backwater ponds bordering the lower Grindstone Creek, albeit in restricted numbers. In addition, there is a large population of map turtles present, and an eastern spiny soft shell turtle (Trionyx spiniferus spiniferus) was sighted on two occasions in 1984 and one specimen was caught in 1982. This latter species is considered extremely rare and, at one time, was thought to have been extirpated from Lake Ontario (Campbell, 1977).

Windermere Basin: Midland painted turtle and common snapping turtle are found in the Basin.

Van Wagner's Ponds: The abandoned railway bed which bisects the ponds provides nesting sites for common snapping turtles and midland painted turtles.

Contaminants in Turtles

In a study of organochlorine levels in snapping turtle eggs from ten sites in southern Ontario, eggs from Hamilton Harbour had the highest levels of PCBs (8.59 mg/kg, wet weight), oxychlordane (0.074 mg/kg), trans-nonachlor (0.02 mg/kg) and dieldrin (0.06 mg/kg) (Struger et al., 1989). The significance of these contaminants in snapping turtles is unknown, although in another study, hatching deaths and deformities were correlated with levels of chlordane (Bishop, CWS, pers.comm.). Hatching deaths and deformities were examined at five sites (Hamilton Harbour, Lynde Shores Creek (Whitby), Cranberry Marsh (Whitby), Long Point (Lake Erie), and Algonquin Park. Hatching deaths were approximately 40% at both Hamilton Harbour and Lynde Shores Creek compared to 10% at the other sites. Deformities, however, were highest at Cranberry Marsh (28%) compared to the other sites (0-2%). In 1986, snapping turtle egg contents from Hamilton Harbour were significantly more contaminated with the pesticides

pp'DDE, HCB, α-chlordane and trans-nonachlor than those from Long Point, Algonquin Park and Cranberry Marsh. However, the HCB and PCB concentrations in eggs from Hamilton Harbour and Lynde Shores Creek were similar. This suggests that turtles in sites such as Hamilton Harbour and Lynde Shores Creek, which are connected to Lake Ontario, are subject to contaminants from the Lake.

2.3.3.4 Mammals

Cootes Paradise: Sixteen species of large mammals occur here. They range from a small mobile herd of less than 20 white-tailed deer (Odocoileus virginianus), which roam freely in distinct travel corridors between the north shore of Cootes Paradise and the Niagara Escarpment, to a large and well distributed population of raccoon (Procyon lotor), which intermixes with high density housing on the south shore. The principal semi-aquatic mammals are mink (Mustela vison), muskrat (Ondatra zibethica) and beaver (Castor canadensis). One beaver was recorded living in a bank den in the lower reaches of Spencer Creek in 1984. The muskrat population, estimated at less than 100 individuals, is confined to small localized pockets of emergent vegetation, primarily cattail (Typha sp.) and manna grass (Glyceria maxima), which rim the Cootes Paradise basin. Muskrats are concentrated in west pond and in bank dens along Spencer Creek. Mink are present in unconfirmed numbers and are commonly associated with the streams of the north shore.

Hendrie Valley/Carroll's Point: Muskrats are found along the Grindstone Creek wherever suitable habitats exist. Bank dens and lodges in the ponds are currently utilized. In 1984, 30 individuals were counted and in 1985, 17 individuals were live-trapped along the creek. Mink were confirmed in 1984 but not quantified and beaver(s) are currently present.

Windermere Basin: Mammals found around the Basin include muskrat and eastern cottontail (Sylvilagus floridanus).

2.3.3.5 Summary/Background

This section of the report has described the existing conditions for fish and wildlife in Hamilton Harbour and Cootes Paradise. Although there still remain some areas of quality habitat, in general, it can be said that habitat in the area has been significantly degraded. Remedial actions have significantly (>90%) reduced phosphorus, ammonia, organic and metal loadings to the harbour. Additional measures are proposed in the RAP that will restore water quality to support healthy fish and wildlife populations. Unfortunately, much of the habitat damage which has occurred over the last 200 years is irreversible. Experience from other degraded ecosystems that have undergone water quality improvements suggests that the desired response of fish and wildlife populations to remedial actions will not occur by itself. These degraded ecosystems are very stable and have internal mechanisms for maintaining their existence. In order to improve conditions for fish and wildlife, direct intervention is necessary.

3.0 THE DEVELOPMENT OF THE CONCEPT OF HABITAT RESTORATION

The Concept for Fish and Wildlife Habitat Restoration in Hamilton Harbour and Cootes Paradise is a component of the Remedial Action Plan for Hamilton Harbour (RAP). To understand its development, it is necessary to understand how the RAP was prepared. The following section gives a brief overview of the RAP process and the steps in the development of the Concept (Figure 8).

Ministry of the Environment Initiative 1985.

While concern had been raised for several decades about the water quality of Hamilton Harbour, there were two actions which provided a catalyst for organized action by all levels of government and the public. The first of these was the release in 1985 by the Ontario Ministry of the Environment of a report entitled Hamilton Harbour Technical Summary and General Management Options. It was also in 1985 that Canada and the US were asked by the International Joint Commission to develop Remedial Action Plans (RAPs) at 42 "Areas of Concern" -- severely polluted places around the Great Lakes. Hamilton Harbour was one of these Areas of Concern.

The Hamilton Harbour Technical Summary and General Management Options report provided a number of options for remediating the problems in Hamilton Harbour. It was based on the investigations carried out by the Ontario Ministry of the Environment in the 1970s and early 1980s, and on a series of industrial and municipal pollution control programs that were carried out in parallel with these studies. Following the release of the report, in the spring of 1986 the Minister of the Environment for Ontario called for public consultation on the proposed remedial program. It was at this time that a Stakeholder Group was formed by Environment Ontario and Environment Canada to discuss and advise on the plan to be undertaken." (draft RAP II P.1)

Remedial Action Plan: Stage 1

In June of 1986, a 48 person Stakeholder group was set up to guide the development of a Remedial Action Plan for Hamilton Harbour. The group included representatives from four levels of government, landowners, industries, environmental, and other citizen and interest groups. The Stakeholders were to provide ongoing advice during the plan's development. In addition, at key points, public consultation was carried out to inform the general public of the RAP's progress and receive feedback. In September 1986, the Stakeholders submitted an Interim Report to both the provincial and federal Ministers of the Environment. This Interim Report outlined the principles, water uses and goals they wished to see addressed in the RAP. The goals relating to fish and wildlife were the following:

> "THAT water quality and fish habitat should be improved to permit an edible, naturally reproducing fishery for warm water species. Water and habitat conditions in Hamilton Harbour should not limit natural reproduction and the edibility of cold water species."
>
> "THAT healthy and self-sustaining resident and non-resident wildlife populations should be enhanced on a Harbour wide basis through water quality improvements and habitat rehabilitation and protection".

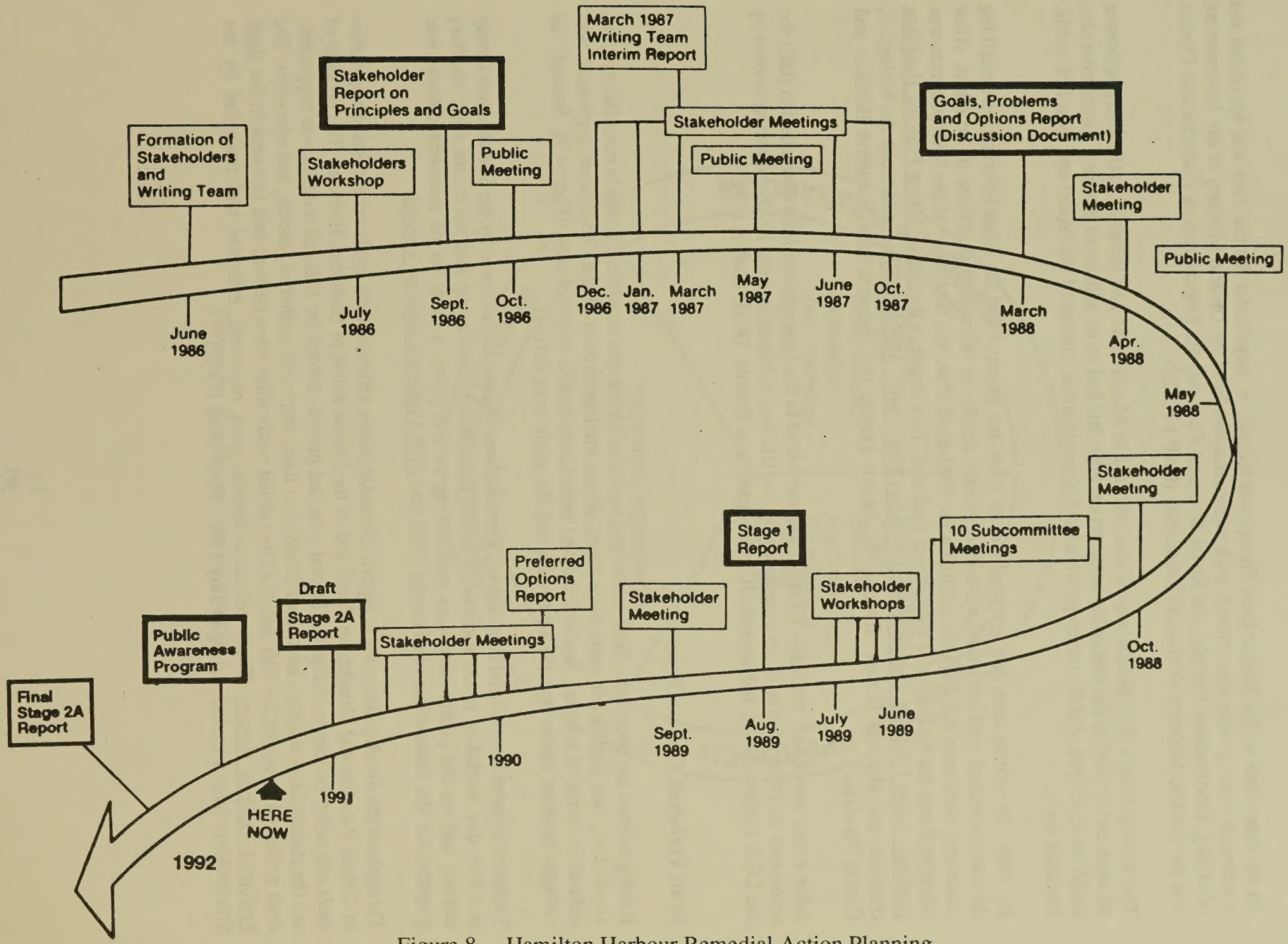


Figure 8. Hamilton Harbour Remedial Action Planning

At the same time as the Stakeholders Group was formed, a coordinator for the Plan was appointed and a technical writing team was formed, with representatives from the Ontario Ministry of the Environment (OMOE), Environment Canada, the Royal Botanical Gardens, the Department of Fisheries and Oceans and the Ontario Ministry of Natural Resources. (RAP I P.122)

The writing team's first interim report was released in March 1987 and included preliminary estimates of costs and identified the remaining information gaps that had to be addressed before a substantive plan could be developed. Public meetings were held to explain the content of the report and to solicit public feedback on it.

By 1988, the writing team had prepared a draft RAP that incorporated the latest information describing the environmental problems, and submitted greater details on the remedial actions to be taken. After comments were received from the public on the 1988 draft Plan, the first stage of the RAP program was completed and the RAP Stage I Report was finalized. This report -- Remedial Action Plan for Hamilton Harbour, Stage 1 Report: Environmental Problem Definitions, March 1989) -- addresses the biological, chemical and physical factors affecting the aquatic system that includes both Hamilton Harbour and Cootes Paradise.

After it was completed. the Stage 1 Report was submitted to the International Joint Commission (IJC) for comments in 1989. Notice of its acceptance by the IJC was received in June 1990, following review by the COA Review Board and several IJC committees and Boards. (RAP draft II P.2)

Draft Preferred Options Report

Having defined the problems, those associated with the RAP began to address possible remedial options. To do this, two significant steps were taken. First, implementation of the "ecosystem approach" was defined in terms of societal, institutional and technical/scientific requirements, (Figure 9). Second, the linkages between inputs into the ecosystem and the goals were defined.

Technical options for remedial actions were identified and intensively reviewed by the Stakeholders Group in a four day workshop in the summer of 1989. Based on that workshop and advice on other ancillary matters and on the public comments received up to that point, a draft set of recommendations was prepared for the Stakeholders in January 1990 (the draft Preferred Options Report).

Throughout the development of this report, the stakeholders affirmed their goals for increased vegetation in Cootes Paradise and Grindstone Creek and in the littoral zones of Hamilton Harbour. The concept of reefs and other devices to shelter the littoral zone and provide habitat for fish and wildlife was supported, and the stakeholders strongly advocated diversity of uses, improved aesthetics, access, and education. The draft preferred concepts for fish and wildlife habitat restoration were defined and included in the draft Preferred Options Report. Those recommendations were reviewed, extended and reworded by the Stakeholders over a period ending in July 1990. (RAP draft II P.2)

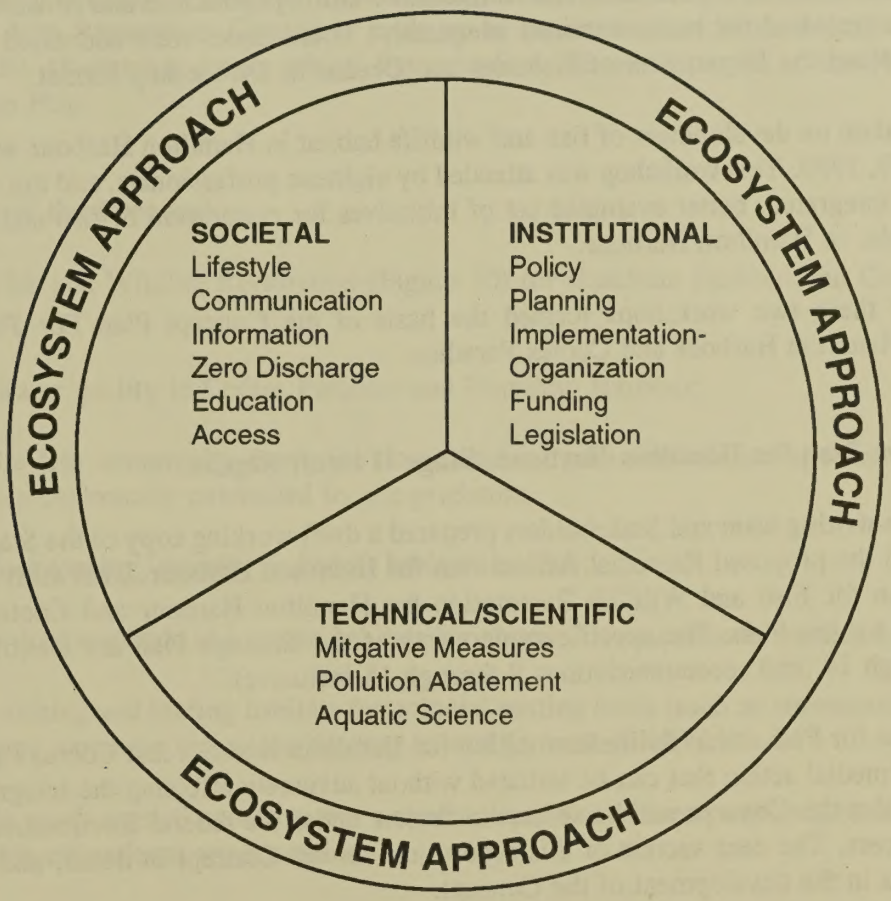


Figure 9. The Ecosystem Approach

Cootes Paradise Restoration Workshop

A workshop on restoration of the Cootes Paradise marsh was attended by nineteen professionals on September 25 and 26, 1990 at CCIW and the Royal Botanical Gardens. This was held so that measures to provide habitat for fish, or wildlife, or other purposes including reduction of pollutants, could be fully evaluated on a broad basis. Previously, options and/or priorities had not been assessed using a comprehensive set of criteria. Consequently, the full extent of benefits, possible conflicts, questions of permanence and self-sustaining features, risk to fish and wildlife populations and consumers of exposures to contaminants toxic had not been examined adequately. These issues were addressed by the Canadian Wildlife Service and the Department of Fisheries and Oceans in a workshop format.

A second workshop on development of fish and wildlife habitat in Hamilton Harbour was held at CCIW on November 20, 1990. This workshop was attended by eighteen professionals, and the major output was a more closely integrated, better evaluated set of initiatives for restoration of fish and wildlife habitat, wherever feasible, in Hamilton Harbour.

The product of these two workshops formed the basis of the Concept Plan For Fish and Wildlife Restoration of Hamilton Harbour and Cootes Paradise.

Remedial Action Plan for Hamilton Harbour, Stage II Draft Report.

In July 1991, the writing team and Stakeholders prepared a draft working copy of the Stage II Report that outlined in detail the proposed Remedial Action Plan for Hamilton Harbour. This draft report identifies the Concept Plan for Fish and Wildlife Restoration for Hamilton Harbour and Cootes Paradise as a remedial option for the Plan. The specific components of the Concept Plan are identified as potential actions 10 through 14, and recommendations 9 through 15 inclusive).

The Concept Plan for Fish and Wildlife Restoration for Hamilton Harbour and Cootes Paradise has been identified as a remedial action that can be initiated without adversely affecting the integrity of the RAP. It is understood that the Concept will be subject to review under the federal Environmental Assessment and Review Process. The next section of this report outlines the Concept in detail, and Chapter 5 lays out the next steps in the development of the Concept.

4.0 PROPOSED CONCEPT FOR FISH AND WILDLIFE HABITAT RESTORATION

4.1 Proponents

This report was prepared by the Fish and Wildlife Restoration Steering Committee for Hamilton Harbour and Cootes Paradise. The Steering Committee reports to the Bay Area Restoration Council, which is monitoring the implementation of all the remedial actions under the Hamilton Harbour Remedial Action Plan. The Bay Area Restoration Council is made up of representatives of the Hamilton Harbour RAP Stakeholders, the 48-member group which has overseen the development of the Hamilton Harbour Remedial Action Plan.

4.2 Nature of the Proposal

The goals for Fish and Wildlife Restoration (Figure 10) for Hamilton Harbour and Cootes Paradise are to:

1) improve water quality in Cootes Paradise and Hamilton Harbour;

2) to alter the fish community from one dominated by pollution tolerant species such as carp and alewife to a community controlled by top predators;

3) to provide spawning, nursery and adult habitats for fish;

4) to recover lost wetlands and create habitats for shorebirds, waterfowl, reptiles and mammals;

5) to create nesting and loafing habitats for colonial nesting birds (such as cormorants, black-crowned night herons, common terns) and feeding habitat for waterfowl; and

6) to provide much needed access to the waterfront and the restored wetland, to improve aesthetics, and provide educational opportunities.

Remedial actions to restore fish and wildlife populations emphasize the construction of marsh and littoral habitats at several locations in Hamilton Harbour and Cootes Paradise. The diverse needs of a complex urban setting have been considered, which is why the proposal contains options for fishing piers, canoe launches, access, interpretive centres, enhanced aesthetics, education and wildlife viewing platforms. In addition to creating new sport fishing and wildlife appreciation opportunities, this project will improve access to the waterfront, increase opportunities for public education, develop a strong public advocacy through participation in marsh restoration, improve aesthetics, and eventually lead to further improvements in water quality.

Habitat creation is viewed as both a goal and a remedial action that will sustain the newly established ecosystem year after year. For example, restoration of the Cootes Paradise marsh will do more than house wildlife and fish. It will also provide a sink for nutrients from the Dundas STP, it will trap contaminants and sediments from the Spencer Creek watershed, and it will reduce fetch, thereby reducing wind driven resuspension of sediments in addition to stabilizing the loose silt bottom. In effect, the habitat

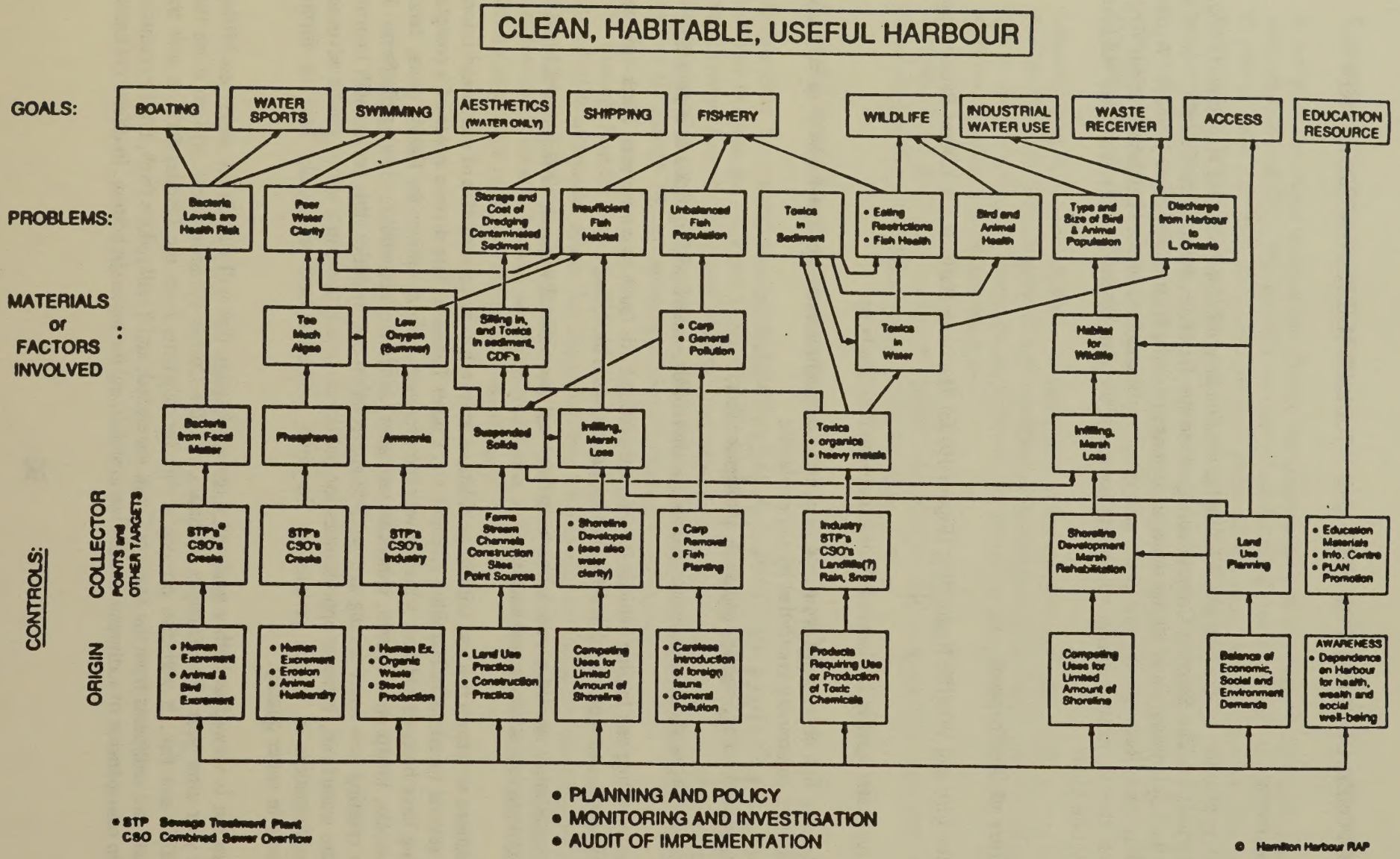

CLEAN, HABITABLE, USEFUL HARBOUR
GOALS:
BOATING
WATER SPORTS
SWIMMING
AESTHETICS (WATER ONLY)
SHIPPING
FISHERY
WILDLIFE
INDUSTRIAL WATER USE
WASTE RECEIVER
ACCESS
EDUCATION RESOURCE
PROBLEMS:
Bacteria Levels are Health Risk
Poor Water Clarity
Storage and Cost of Dredging Contaminated Sediment
Insufficient Fish Habitat
Unbalanced Fish Population
Toxics in Sediment
• Eating Restrictions • Fish Health
Bird and Animal Health
Type and Size of Bird & Animal Population
Discharge from Harbour to L. Ontario
MATERIALS OF FACTORS INVOLVED:
Too Much Algae
Low Oxygen (Summer)
Silting in, and Toxics in sediment, CDF's
• Carp • General Pollution
Toxics in Water
Habitat for Wildlife
Bacteria from Fecal Matter
Phosphorus
Ammonia
Suspended Solids
Infilling, Marsh Loss
Toxics • organics • heavy metals
Infilling, Marsh Loss
CONTROLS:
COLLECTOR POINTS and OTHER TARGETS
STP's* CSO's Creeks
STP's CSO's Creeks
STP's CSO's Industry
Farms Stream Channels Construction Sites Point Sources
• Shoreline Developed • (see also water clarity)
• Carp Removal • Fish Planting
Industry STP's CSO's Landfills(?) Rain, Snow
Shoreline Development Marsh Rehabilitation
Land Use Planning
• Education Materials • Info. Centre • PLAN Promotion
ORIGIN
• Human Excrement • Animal & Bird Excrement
• Human Excrement • Erosion • Animal Husbandry
• Human Ex. • Organic Waste • Steel Production
• Land Use Practice • Construction Practice
Competing Uses for Limited Amount of Shoreline
• Careless Introduction of foreign fauna • General Pollution
Products Requiring Use or Production of Toxic Chemicals
Competing Uses for Limited Amount of Shoreline
Balance of Economic, Social and Environment Demands
AWARENESS • Dependence on Harbour for health, wealth and social well-being
• PLANNING AND POLICY
• MONITORING AND INVESTIGATION
• AUDIT OF IMPLEMENTATION
* STP Sewage Treatment Plant
CSO Combined Sewer Overflow
© Hamilton Harbour RAP

Figure 10. Clean, Habitable Useful Harbour

restoration project will modify the factors that were initially responsible for the loss of the marsh.

There are two parts to this proposal. The first addresses habitat restoration in Hamilton Harbour in five sub-areas. The second part of the proposal is for marsh restoration in Cootes Paradise and Grindstone Creek. The eight components of the proposal are:

COMPONENTS OF HABITAT RESTORATION CONCEPT:

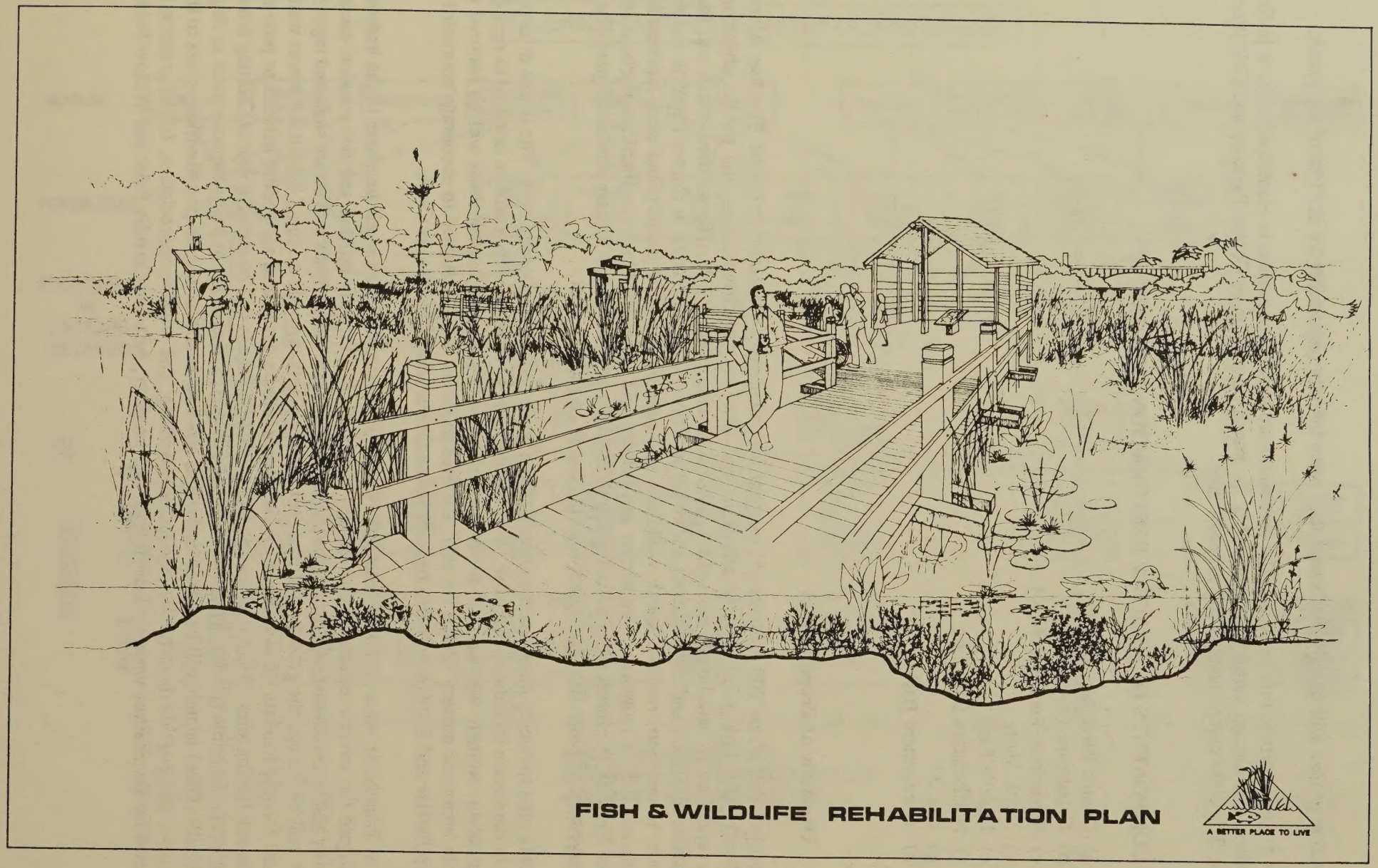
a) Cootes Paradise
b) Grindstone Creek
c) Waterfront Park and Pier 4
d) North Shore
e) LaSalle Park
f) Northeastern Shoreline
g) Pier 27
h) Windermere Basin

4.3 Overview of Proposal

The project will create 200 hectares of emergent and submerged vegetation in Cootes Paradise. Marsh boardwalks will link existing parks and trails and improve waterfront access and public education. Observation towers will be constructed for wildlife viewing (Drawing 1). The restored marsh will trap sediments, nutrients, and contaminants and result in improved water quality in Cootes Paradise and the harbour. In addition, restored marsh vegetation will provide important nursery and adult habitats for wildlife and fish. A temporary carp barrier and fishway will be installed between Hamilton Harbour and Cootes Paradise to protect the developing marsh from the adverse effects of carp while still permitting the movement of other fish species between the marsh and the harbour.

The only pike spawning marsh in Hamilton Harbour is located in Grindstone Creek. The marsh dries out early in the season stranding young fish. A new water inlet and low-head dam will be installed to remedy this problem. Aquatic vegetation in the lower Grindstone Creek and Sunfish Pond will be restored to provide important nursery habitat for fish. Exposed mudflats will be retained to encourage shorebirds. A carp barrier and fishway will also be installed in the mouth of Grindstone Creek.

Narrow islands, or other forms of breakwaters, will be constructed at strategic locations in the harbour to mitigate the adverse effects of erosion and wave action. Currently erosion and wave action causes turbidity and limits submerged aquatic plants in the littoral zone. The islands will create sheltered lagoons which will encourage the growth of submerged aquatic plants, provide essential habitat for warm water fish and feeding habitats for waterfowl. Some islands will be designated as wildlife habitats to provide nesting and loafing sites for colonial nesting birds. Wildlife islands will contain appropriate nesting boxes to encourage desirable species. Measures will be employed to discourage unwanted species such as ring-billed gulls. Other islands will be linked by bridges and boardwalks to encourage pedestrian access to the waterfront and provide opportunities for fishing, walking, and wildlife appreciation. Island creation is proposed for the shallow waters off the former Lax property, between Carrolls Point and Willow Point,



Drawing 1. Conceptual drawing of the restored Cootes Paradise Marsh showing the boardwalk, observation towers, nesting boxes for wildlife and diverse natural habitats for fish and wildlife.

off LaSalle Park, in the north east corner of the harbour near CCIW, and on the east shore south of the canal near Pier 27. Final site selection will depend upon partner support and concerns raised during the Environmental Assessment and Review Process.

The amount of habitat to be created is listed by sub-area in Table 4.

Table 4. Habitat creation at each site

Location	Fish Habitat (ha)	Wildlife Habitat (ha)	Littoral Edge (m)	Trails (m)
Cootes Paradise	250.0	250.0	0	2000
Grindstone Creek	20.0	20.0	0	1000
Pier 27	3.8	0.1	500	0
Northeastern Shoreline	18.4	0.3	2,920	500
LaSalle Park	11.9	0.2	2,340	1,170
North Shore	18.0	0.6	2,550	0
Waterfront Park and Pier 4	22.1	0.4	2,600	1,300
Total	**344.20**	**271.60**	**10,910.00**	**5,970.00**

In all, 344 hectares of new fish habitat will be created, along with 271 ha of new wildlife habitat. An additional 10 km of littoral edge for fish will be provided, and an additional 6 km of waterfront access for people. In summary, the benefits of the Concept Plan for Fish and Wildlife Restoration for Hamilton Harbour and Cootes Paradise will be the following:

- Improved water quality in Cootes Paradise and Hamilton Harbour by trapping nutrients, sediments, and contaminants in the created marshes and reducing erosion and sediment resuspension behind the islands.

- Improved fish community (fewer carp, alewife, white perch and gizzard shad; more pike, bass and perch).

- Improved plant diversity (from 4 species to approximately 25).

- Increased nesting and loafing habitats for colonial birds, and control of ring-billed gulls and

Canada geese.

- Increased abundance and diversity of waterfowl and birds in the restored Cootes marsh.

- Maximum diversity of beneficial uses to resource users such as: improved waterfront access, education, fishing, wildlife appreciation, improved aesthetics and enhanced use of the harbour for small boats.

- Linkages with ongoing pollution control and waterfront development projects to enhance beneficial uses in Hamilton Harbour.

4.4 Long Term Monitoring of Progress

A long term monitoring program was developed for Hamilton Harbour as part of the Stage II Remedial Action Plan. In this document, agencies have identified indicators of successful habitat restoration, a time frame for monitoring, and responsible agencies. Targets for the restored fish community and wildlife community are listed below.

Table 5. Targets for a restored fish community in Hamilton Harbour

Fish species	Composition (%)	Biomass (Kg/Ha)
Piscivores (pike and bass)	45-60	116-150
Planktivores (alewife, white perch)	0.8-1.3	2-3
Hervbivores (gizzard shad)	<0.5	O.1
Benthivores (carp, bullhead)	40-50	103-130

Table 6. Targets for a restored wildlife community in Hamilton Harbour

Species	Target
Double-crested cormorants	200 pairs
Black-crowned night herons	200 pairs
Ring-billed gulls	reduce to 5000 pairs
Common terns	more than 600 pairs
Herring gulls	reduce to 350 pairs
Caspian terns	more than 200 pairs

4.5 Details of Fish and Wildlife Habitat Restoration

4.5.1 Cootes Paradise (Marsh Restoration)

Cootes Paradise is an 840 ha wildlife sanctuary located at the extreme western end of Hamilton Harbour. It has been classified by OMNR as a class 1 wetland, an area of natural and scientific interest, and as an environmentally sensitive area. It is historically important as a wildlife staging area.

One hundred years ago, Cootes Paradise was a marsh throughout its entire area. To the early settlers, the fact that the area was a marsh with a high abundance of wetland-dependant wildlife made the area a "Paradise". Fifty years ago, the marsh occupied 85% of the available 250 ha. Between 1934 and 1985, 85% of the emergent vegetation disappeared. The open water area of Cootes Paradise is virtually devoid of aquatic plants. In addition to reduced abundance, species richness has declined from a high of 25 species in 1946 to 4 in 1987.

The high silt concentrations in the water make the open water area aesthetically unpleasant and useless to all but the most undesirable fish. The number and diversity of fish, waterbirds and other wetland dependant wildlife in Cootes Paradise is limited by the amount and quality of vegetation (marsh) now available. Though it remains a very important potential wildlife habitat on the Lake Ontario shoreline, "Paradise" has been essentially lost.

The loss of marsh vegetation in Cootes Paradise has resulted in a significant reduction of resident wetland-dependant wildlife (skewing species diversity towards scavenger types). Food quality for migrant waterfowl has declined, reducing the stopover/staying value of a strategic region of the lower Great Lakes. The loss of the Cootes marsh has resulted in a change in the hydrologic functions at the lower end of Spencer, Borer and Chedoke watersheds; a significant loss of spawning and nursery habitat for warm water fish; uncontrolled sediment distribution from Spencer Creek into Cootes and Hamilton Harbour; unstable bottom sediments that are easily resuspended by wind; nutrient export from the Dundas STP and

the combined sewer overflow in Chedoke Creek, and finally, the loss of a significant urban educational opportunity for the 300,000 visitors to the Royal Botanical Gardens annually.

Sources of the Problem

Recent research carried out by the Royal Botanical Gardens, NWRI and DFO has determined the following sources of stress on the Cootes Paradise marsh vegetation:

- Spencer Creek, the main tributary, has carried increased loadings of suspended solids to Cootes Paradise since the 1940s, reducing the depth and changing the substrate quality.

- Nutrient enrichment due to STP effluent, CSO discharge and watershed inputs (creeks).

- Wind and waves resuspend the sediment creating highly turbid conditions in the water which in turn reduces light penetration and prevents the growth of submerged plants.

- The introduced carp inhabit the area in such dense numbers, particularly during the growing season, as to have direct impact on emergent and submerged plants and indirect impacts on submerged plants during feeding and spawning activities.

- The timing of annual water-level regime of Lake Ontario is "out of synchronization" with the normal growth cycle of aquatic plants, thereby restricting them to small amounts of littoral habitat which fringe the basin.

Recommended Solutions

The recommended approach incorporates the most desirable features of many options in a strategy to rehabilitate all of Cootes Paradise as one system. It consists of i) pollutant reduction at source, with an emphasis on reducing sediment inputs, ii) carp control at the outlet combined with other manipulations of the fish community, iii) reduction of fetch and provision of shelter with berms and islands and, iv) plantings of aquatic plants and measures to extend existing macrophyte beds. The proposed methods of accomplishing this are outlined below.

Carp Control: The outlet to the Harbour is about 4m deep and 15-20m wide. This would be restructured to contain a two-way fish trap adjacent to the shore and a removable self-cleaning screen barrier which would be operated during the migration of carp, possibly from March through October. Desirable fish can be passed into or out of Cootes Paradise.

Stabilization of mudflats with emergent vegetation: Some sites, adjacent to existing marshes particularly, should colonize naturally if protected from carp and high concentrations of silt. Other sites should be selected for suitability for planting of emergent plants. Selection of planting sites, appropriate native plant species, timing and methods requires highly skilled supervision. Sites selected for either natural colonization or planting may need to be protected from wave action and resuspension of sediments, depending on the exposure of each site. Log booms (chains of connected timbers or logs of hefty proportions of any desired length) can be floated and set out temporarily in the spring. They may rest on the bottom at low water, which enhances the protection they offer. They can be retrieved at high water. There are several sites where this method can be used.

Promote colonization by submerged and emergent plants: Cumming Cockburn Limited prepared a marsh restoration plan for Cootes Paradise in June 1991. The plan provides a "low tech" approach to restoring the marsh which is based on selective plantings monitoring for success, followed by successive plantings with appropriate successful species. Temporary exclosures (screened off areas) are proposed to exclude both fish and wildlife from the plots where vegetation is being re-established. Fish, primarily carp but also suckers and other bottom feeders, can uproot delicate young plants. Feeding activities by fish also resuspend sediments, clouding the water and blocking light penetration essential for plant growth. Waterfowl can be especially damaging through mechanical disturbance to newly established plants as well as direct herbivory on the plants. During the summer of 1991 McMaster University constructed a series of experimental exclosure plots and success rates indicated that the exclosure technique should be pursued when restoring emergent vegetation.

4.5.2 Grindstone Creek (Marsh Development)

The emergent marsh in Grindstone Creek declined from 37.8 ha in 1934 to 5.1 ha by 1985. Most of the loss occurred in the area of the Valley Inn Road. Possible factors responsible for marsh loss include nutrient addition from the Waterdown STP, damage by carp, siltation, reduced light penetration, and increased water levels.

The four areas of concern are the Cherry Hill Gate marsh, Long Pond, the Elbow and Sunfish Pond. Carp likely are the main stress in the latter three areas where little marsh remains. The Cherry Hill Gate marsh (about 4 ha) runs parallel to Grindstone Creek and it is connected to the creek at the downstream end. Pike have spawned in the marsh but it drains so early in the spring that larval fish are killed. The three downstream ponds (about 20 ha) would be suitable nursery areas for pike and other species if carp could be controlled. Spawning and nursery areas do not have to be large to support a strong pike population. Largemouth bass probably would spawn in the three downstream ponds.

Carp control

A barrier and two-way fish trap are recommended. The Sunfish Pond outlet bridge is an appropriate location. However, there is insufficient space available at the bridge, so it will be necessary to offset the barrier south of the bridge and fence to control access to that location.

Water level control in the Cherry Hill Gate marsh

A low dam (0.5m) should be built spanning the mouth of the marsh. A set of short stop logs at one point would allow more critical control of residual water level after the spring freshet. The marsh could be drained at the appropriate time by removing stoplogs. A small flow could be maintained through the marsh by tapping into the creek upstream, and piping water to the head of the marsh (which is actually oriented upstream).

Restoration of marsh in the Elbow, Long Pond and Sunfish Pond

Because fetch is low, these sheltered ponds should be colonized by emerged and submerged plants when carp are excluded. Mudflats remaining over part of the Elbow in late summer and fall are well suited for shorebirds and turtles and an Royal Botanical Gardens trail provides access. The Grindstone Creek marsh is a very popular tourist attraction. Efforts to restore marsh habitat would have a high educational

potential and benefit the large number of naturalists who visit the area. Sunfish Pond is one of the most popular fishing spots in Hamilton Harbour at all times of the year. A fishing platform will be constructed on the north side of the road on the west of the bridge.

Establish aquatic plant colonies at the mouth of Grindstone Creek

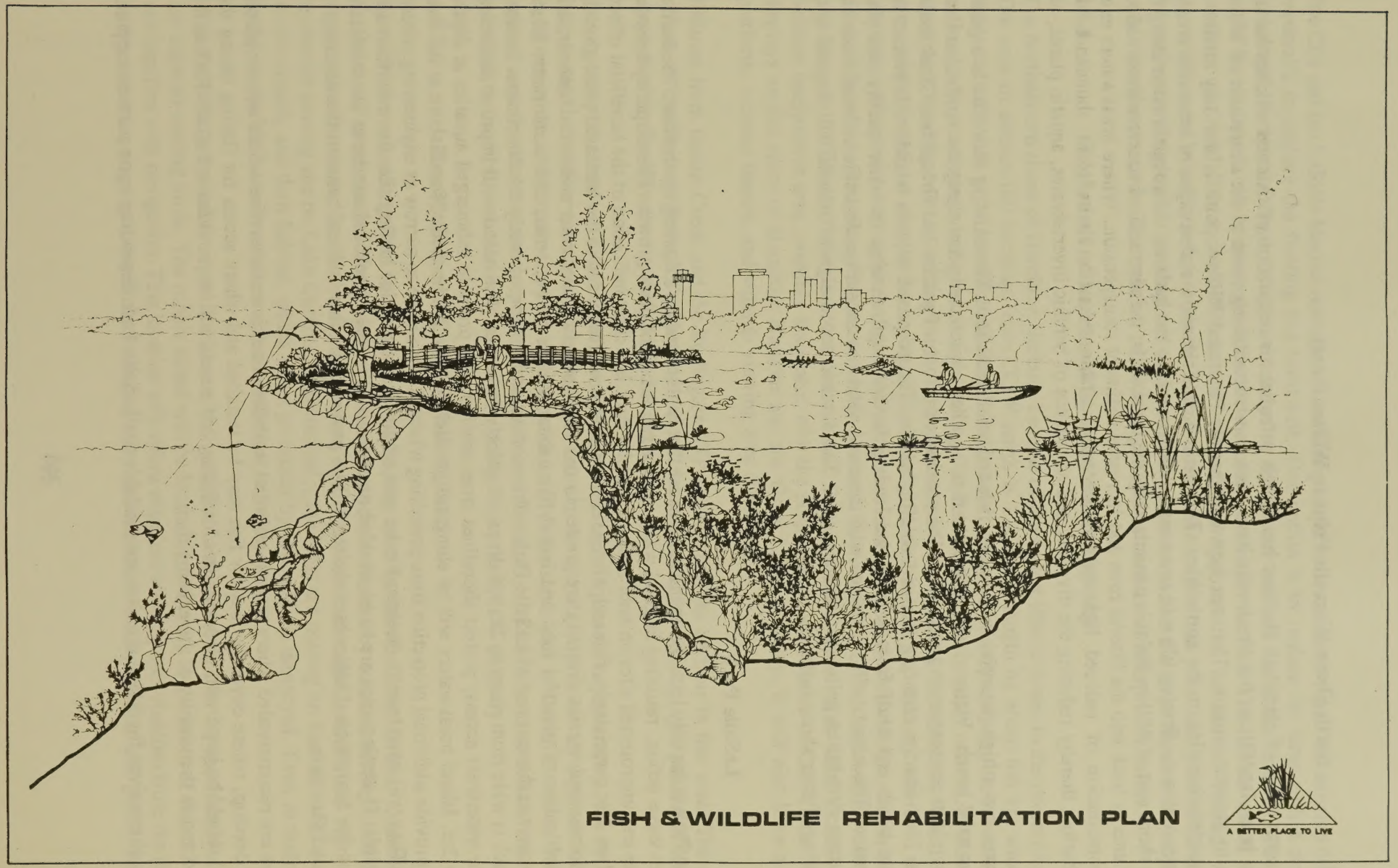
This area supports few aquatic plants; the shallow sediments (1m and less) are soft, and very subject to resuspension. Carp will continue to have access; consequently habitat improvement may be attractive to carp. Establishment of emergents may not be possible, but submerged plants may colonize sheltered areas protected by constructed islands (300m). Such islands will shelter areas with highest potential for submerged plants and lowest potential for carp. A pilot project is recommended before any major expenditure is made on habitat improvement in this area. Requests for funds for this site will not be made to the cleanup fund until the success of remedial options in Sunfish Pond has been determined.

4.5.3 The Waterfront Park and Pier 4 Park

The 2.1 km of shoreline between the proposed Waterfront Park property and the Desjardins Canal represents 14 per cent of the total littoral shoreline in Hamilton Harbour. More importantly, it is the last remaining shallow water habitat on the south shore. Most of the area between Desjardins Canal and the Waterfront Park was filled to accommodate the CNR leaving only a small littoral zone. This narrow strip runs for approximately 1 km from the Desjardins Canal towards the Waterfront Park and has an area of 0.4 km^2. The area is moderately vegetated and represents approximately 10 per cent of the total moderately vegetated habitat in the harbour.

Larval fish surveys found 14 species of larval fish (10 forage and 4 important recreational species), indicating that this area is an important spawning and nursery habitat. Further studies confirmed that there are small numbers of important species such as pike and largemouth bass using this habitat. The community structure (dominated by forage species) and low numbers of sport fish, reflect a stressed fishery limited by poor water quality (from a combined sewer overflow) and a small littoral zone containing reduced numbers (and types) of aquatic plants. While this area is important as existing fish habitat, the real value of the western end of the harbour lies in its potential for rehabilitation. The uncontaminated sand and gravel substrate along the CNR shore is presently the preferred spawning habitat within the harbour for largemouth bass. Remedial actions to reduced algae and suspended solids, combined with increased littoral habitat (islands, groynes) to add structure will encourage plant growth and provide more adult and nursery habitat.

It is proposed to establish littoral embayments along the south shore by building groynes and islands in the 2-3 m depth. As along the north shore, the islands will promote plant growth on the lee shore, provide loafing habitat for colonial-nesting birds, and access to the waterfront in a site where access is restricted by the CNR. A fishing platform is also proposed for this site. Although the placement of islands will depend upon the extent of partner support, creation of islands offshore from the Waterfront Park to Desjardins Canal, linked by bridges and a boardwalk, provides a much needed pedestrian linkage between the Waterfront Park to Cootes Paradise (Drawing 2). An interpretive centre at the Pier 4 Park could be accommodated in existing facilities.



Drawing 2. Conceptual drawing of recreation islands located in the south west area of the harbour between the Waterfront Park and Desjardins Canal. These islands provide essential lagoon habitats for fish and wildlife and greatly improve waterfront access, aesthetics, and recreational opportunities.

4.5.4 North Shore (Carrolls Point to Willow Point)

The north shore of Hamilton Harbour has a high potential for restoration of fish and wildlife habitat. There is no landfilling, but breakwalls have been constructed along most of the shore east of Willow Point to prevent erosion. The area between Carrolls Point and Willow point is the only stretch of unprotected shoreline on the north shore. The banks at this site show recent signs of extensive erosion by wave action confirming it's role as a source of sediments to the harbour. Although erosion along the north shore east of Willow Point is minimized by the breakwalls, the restructured concrete shore reflects wave energy back into the littoral zone and increases sediment resuspension. Where breakwaters exist, the combination of reduced light penetration and unstable substrate limits plant abundance and distribution, thereby reducing the diversity and abundance of benthic invertebrates, aquatic plants, and fish.

This area has a high potential for creating fish and wildlife habitat. The existing shoreline is a gently sloping sand beach. Water clarity is greater than at other unprotected sites along the north shore and aquatic plants are responding positively. The proximity to Cootes Paradise and Grindstone Creek makes this an ideal site for restoring fish and wildlife habitat. The proposed wildlife islands will protect the existing beach and bluff from erosion and lead to further improvements in water quality and plant production. The islands will be planted with trees and shrubs to encourage desirable colonial birds and discourage ring-billed gulls and Canada geese. The number and design of islands will depend upon modelling of near shore currents.

4.5.5 LaSalle Park

LaSalle Park is the only location on the north shore that is protected by a floating tire barrier. The barrier reduces wave action, resulting in good water clarity and excellent plant growth. The disparity between this site and unprotected sites on both sides of LaSalle Park is a clear indication of the beneficial effects of shelter. Not surprisingly, fish and wildlife communities have responded to the increased plant growth. Fish biomass and species diversity are greater in this location than at any other site in the harbour, and the combination of plentiful food and island-like habitat attracts heron, terns, and cormorants. Island breakwaters at the east end of LaSalle Park will be constructed at approximately the 2m contour because the beach is wide from shore to 2m and drops off quickly thereafter. The islands will improve aesthetics, provide waterfront access, protect shorelines from erosion, and promote submerged aquatics at depths of 1 to 2m. Island breakwaters will be elongated parallel to shore but hooked towards shore at the west end to provide additional protection from prevailing winds. They will be as narrow as engineering criteria allow. They will have enough freeboard to be seen readily and to provide loafing sites for waterfowl and other birds. If nesting sites are to be avoided on some islands, then freeboard can be at the minimum required for navigation. Underwater shelter will be provided for fish in areas between the breakwater island and shoreline.

Groynes are recommended where there is potential to shelter a section of shoreline where aquatic plants should develop, where cover devices for fish may be installed and where access for fishing (along the groyne) should be improved. Opportunities for fishing and access will be provided at LaSalle Park at the east end and in the vicinity of the existing dock.

Several alternatives for island creation are available for LaSalle Park depending upon partner support.

The City and the LaSalle Marina Association are facing major renovations to repair the existing dock and eventually to replace the floating tire breakwall. One option is to replace the tires with a string of permanent islands at a depth of approximately 7m in the west end and 2m at the east end. The finger docks would have to be reoriented within the narrower but longer confine. The islands would provide excellent sheltered fish and wildlife habitat and enhance opportunities for access, fishing, wildlife appreciation and possibly a future beach. LaSalle Park is the only access point along the north shore of the harbour with adequate parking and park facilities to accommodate the large number of people who would use the resource. The existing pavilion might also be used as an interpretive centre.

4.5.6 Northeastern Shoreline (Fish and Wildlife Habitat)

The northeastern shore of Hamilton Harbour has one of the widest littoral zones in the present harbour. The area of almost 100 hectares from CCIW north is 1.6 km in length by about 0.6 km wide. It is exposed to the full eight km fetch of Hamilton Harbour, and as a result, turbidity from resuspended sediments is preventing plant growth and limiting fish habitat. The site contains two small islands that are already used by colonial-nesting birds. Expansion of these islands along the east shore would enhance some of the beneficial uses of the harbour, particularly for fish habitat and fishing, waterfowl use, and protection of colonial-nesting birds. Specific nesting sites could be created to encourage some species and discourage others. The site offers considerable potential for restoration of fish and wildlife habitat. Its proximity to CCIW (and the proposed Great Lakes Science Centre) make it an ideal location for an outdoor interpretive area, possibly associated with the proposed Science Centre or CCIW and featuring displays on the story of Hamilton Harbour and the Great Lakes clean-up. It will also have a fishing platform, a canoe launch, and wildlife viewing area (Drawing 3).

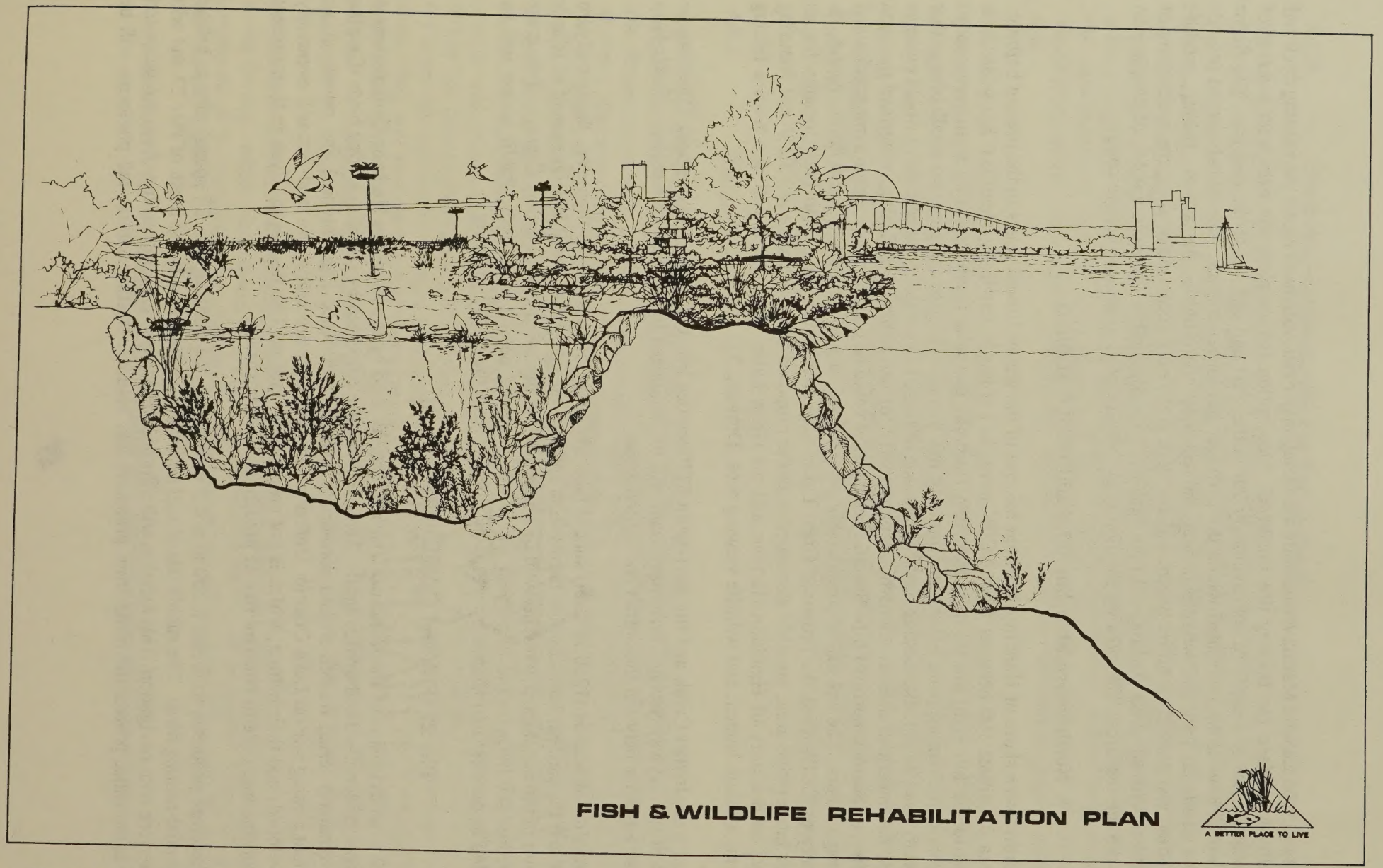
Effluent from Indian Creek and the Burlington STP empties into the harbour in this area. The adverse effects of the Skyway Sewage Treatment Plant will be minimized by developing a pattern of islands to serve as a barrier between the outfall and littoral zone.

Construction of islands (1250 m total) should take advantage of present morphometry, the two Hydro islands and the sandbar (construction berm) from shore to the islands. A possible arrangement of islands is shown in the attachment. Groynes will be constructed at the south side of Indian Creek to deflect the current into the harbour and to prevent waves from entering behind the islands. Public access will be provided to the first two islands by means of a bridge from the CCIW property.

4.5.7 Pier 27 (Fish and Colonial Bird Habitat)

Pier 27 is an extension of the Confined Disposal Facility used by the Hamilton Harbour Commissioners to dispose of contaminated dredge spoils. The area has been colonized by colonial-nesting birds (Caspian terns, common terns, double-crested cormorants and black-crowned night herons) and represents an important nesting site on Lake Ontario. Unfortunately, the birds are nesting on land that will eventually be developed, and their habitat, which is not protected by law, will be destroyed. Even in their present location, the birds are in constant risk of predation and disturbance.

It is therefore proposed to create a 250 m x 4.5 m island to the north of Pier 27 specifically as habitat for colonial-nesting birds. The rubble island will be located immediately to the north of Pier 27 and will not interfere with navigation. This location will afford excellent viewing opportunities from the shore and at the same time, protect the birds from predators and visitors. Nesting habitat and platforms will be



Drawing 3. Conceptual drawing of wildlife islands located in the north east corner of the harbour adjacent to the Canada Centre for Inland Waters. These islands prevent erosion and provide important lagoon habitats for fish and waterfowl and nesting and loafing habitats for colonial-nesting birds such as common and Caspian terns, black-crowned night herons, and cormorants. Viewing platforms will enhance opportunities for wildlife appreciation and education.

provided to encourage nesting of desired species. The island will shelter part of the east shore from the prevailing westerly winds and encourage submerged plants, and excellent habitat for waterfowl and fish. All islands and groynes described in this proposal will comply with the Hamilton Harbour Commissioners specifications for safe navigation and construction. They will consist of a large rubble exterior and an inner core suitable for supporting tree growth. The berms will be approximately 4.5 meters wide at the top with a 2:1 slope. The windward edge will be reinforced by large quarry stone. The lee shore of the islands will be faced with smaller quarry stone. Large boulders will be placed at the base of the slope on both sides to provide adult fish habitat.

4.5.8 Windermere Basin (Colonial-Nesting Bird Habitat)

Windermere Basin has recently been dredged and partially filled as one of the remedial options to treat contaminated sediments and to provide a settling basin for suspended solids from Red Hill Creek and the STP. Windermere, in its present form is not good fish and wildlife habitat. However, it is anticipated that other remedial options to reduce contaminant inputs to the STP and improved treatment efficiency will result in the discharge of uncontaminated effluent into Windermere Basin. At that time, dredging should stop and the basin should be allowed to fill with clean sediment and resume its proper function as a tributary to Red Hill Creek. This is especially important if remedial actions are applied to improve fish and wildlife habitats upstream. In the meantime, it probably will be necessary, in order to sustain dwindling numbers of common terns in the lower Great Lakes, to encourage the nesting colonies of terns on the Windermere dykes. At the same time, sites should be created to attract terns to islands of the proposed conservation area (CCIW waterlot) where their future probably is much more secure from disturbance than at Windermere.

5.0 THE NEXT STEPS IN THE PROCESS

The next steps in the federal Environmental Assessment and Review Process (EARP) of developing the Concept for Fish and Wildlife Habitat Restoration in Hamilton Harbour and Cootes Paradise are illustrated in Figure 11. The first stage is the **Concept Definition** Stage which is complete. This report represents a summary of the Concept which has been prepared to guide discussion.

The next stage is **Preliminary Scoping Consultation**. There are three aspects to this: funding; ecological and social scoping; and Land/Project Owners. With regard to funding, habitat restoration and creation will cost approximately 12.6 million dollars. The concept for fish and wildlife restoration was presented to the Department of the Environment's Great Lakes Cleanup Fund. The proposal was accepted and funding for 4.2 million dollars over three years was approved conditional on Partner contributions for the remaining 8.4 million dollars needed to complete the project. The Fish and Wildlife Restoration Steering Committee, which represents the Stakeholders, is soliciting support from public and private partners for this important project.

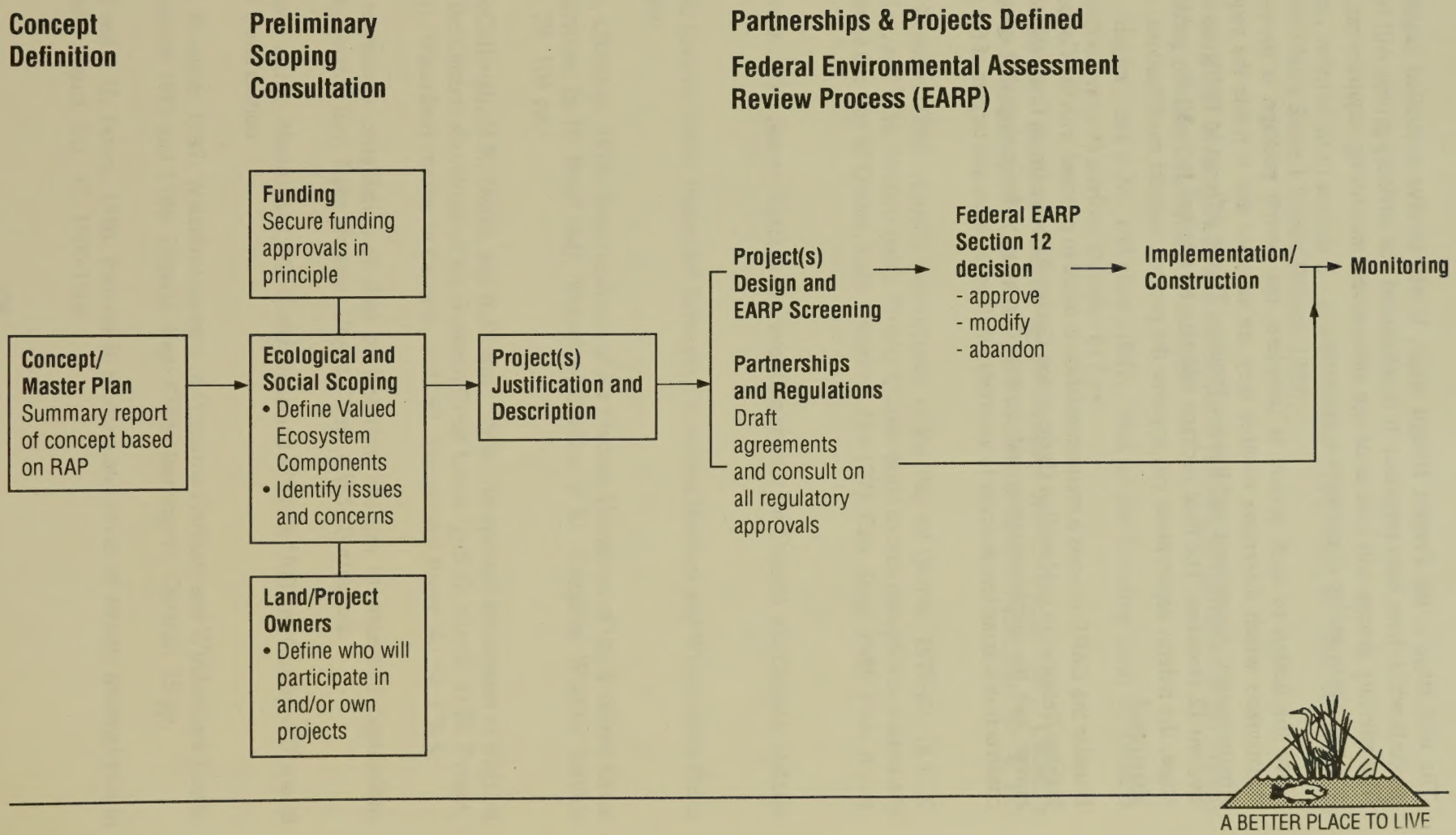
Ecological and social scoping involves the identification of issues and concerns relating to the Concept and its eight components. These issues and concerns may arise in Open Houses, or in written responses to this report. The scoping stage also requires the definition by the public of "Valued Ecosystem Components". These may refer to the natural environment (e.g. the ability to support population of cormorants), or the social environment (e.g. the need to preserve views of the Bay). The identification of issues and concerns, and the identification of Valued Ecosystem Components are needed in order to make decisions about which projects to proceed with.

Also in this stage, negotiations are conducted with the major land owners who may be affected by the Concept. These include the Royal Botanical Gardens, the Hamilton Harbour Commissioners, and Environment Canada's Centre for Inland Waters. The object is to define who will participate in the further development of the Concept, and to reach agreement on issues such as long-term ownership, liability, maintenance, and monitoring.

The results of the activities conducted in the **Preliminary Scoping Consultation** will be incorporated into a document outlining the **Project Justification and Description**. This document will specify which of the eight initiatives outlined in the Concept for Fish and Wildlife Habitat Restoration in Hamilton Harbour and Cootes Paradise should proceed forward to the engineering design stage. The **Project Justification and Description** report is a public document, and will be released for a thirty day public review.

Figure 11:

The Fish & Wildlife Habitat Restoration Project Hamilton Harbour and Cootes Paradise Planning Process


Concept Definition
Preliminary Scoping Consultation
Partnerships & Projects Defined
Federal Environmental Assessment Review Process (EARP)
Funding
Secure funding approvals in principle
Concept/ Master Plan
Summary report of concept based on RAP
Ecological and Social Scoping
• Define Valued Ecosystem Components
• Identify issues and concerns
Land/Project Owners
• Define who will participate in and/or own projects
Project(s) Justification and Description
Project(s) Design and EARP Screening
Partnerships and Regulations
Draft agreements and consult on all regulatory approvals
Federal EARP Section 12 decision
- approve
- modify
- abandon
Implementation/ Construction
Monitoring
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The next stage is the **Project Design** stage. It will involve a detailed examination of the individual projects which have been proposed. It is anticipated that advisory groups will be set up for each project. The advisory groups will look at design alternatives, monitoring requirements, environmental impacts, and mitigation and/or compensation measures.

Once the design of each project is complete, the overall package is forwarded to various federal departments which determine whether they are satisfied that it meets the requirements of the federal Environmental Assessment and Review Process. This is referred to in Figure 11 as the **Federal EARP Section 12 Decision**. The final package will also be released for a 30 day public review period. At this stage, the federal departments can approve the project, suggest modifications, or recommend that it be abandoned.

If under the EARP process a recommendation is made to proceed with the Concept for Fish and Wildlife Habitat Restoration in Hamilton Harbour and Cootes Paradise (in its final refined form), the project then moves into the implementation and construction stage. Monitoring will occur during and after the construction is complete in order to ascertain whether the aims and targets of the programs are being met.

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